SECTION 601 CONCRETE STRUCTURES:

601-1 Description:

The work under this section shall consist of furnishing all materials and constructing structures or parts of structures to the forms, shapes and dimensions shown on the project plans and to the lines and grades established by the Engineer and in accordance with the requirements of these specifications. When the structures or parts of structures are precast, the work shall also include transporting and erecting the units.

Concrete structures such as cattle guards, catch basins, median barriers, headwalls, and other small miscellaneous structures of sizes which can readily be precast as units and furnished and installed in place are hereby defined as minor structures. Minor structures, at the option of the contractor, may be either constructed of cast-in-place concrete or furnished and installed as precast units providing they are fabricated in accordance with drawings submitted and approved in accordance with requirements which may be found in the Special Provisions.

601-2 Materials:

601-2.01 General:

Portland cement concrete shall conform to the requirements of Section 1006 for Class S or Class B concrete as shown on the project plans.

Where a strength is shown on the project plans but a class of concrete is not indicated it shall be construed to mean Class S concrete having the required minimum compressive strength shown at 28 days.

Liquid membrane-forming compound shall conform to the requirements of Subsection 1006-2.05.

Materials furnished for expansion joint filler and joint seal shall conform to the requirements of Section 1011.

Materials furnished for water stops shall conform to the requirements of Section 1011.

Preformed bearing pads and elastomeric bearing pads shall conform to the requirements of Section 1013.

Reinforcing steel shall conform to the requirements of Section 1003.

601-3 Construction Requirements:

601-3.01 Foundations:

Foundations for structures shall be placed on suitable earth or rock bearing, on a concrete foundation seal, or on piling, as shown on the project plans. Excavation and backfill shall be

in accordance with the requirements of Subsection 203-5. No concrete shall be placed under water or against water-bearing strata, except where a tremie concrete procedure is allowed by the Engineer.

601-3.02 Falsework and Forms:

(A) Design and Drawings:

The contractor shall be responsible for designing and constructing safe and adequate falsework and forms which provide the necessary rigidity, support the loads imposed, and produce in the finished structure the lines, grades, and dimensions shown on the project plans and established by the Engineer.

Forms shall be any system of structural elements which provides horizontal support or restraint to the lateral pressure of concrete.

Falsework shall be any system of structural elements that provides temporary support for loads from plastic concrete, forms, reinforcing steel, structural steel, loads from placement operations or other related loads, and continues to provide support until the concrete has attained adequate strength and the structure is capable of self-support.

The design load for falsework shall consist of the sum of dead and live vertical loads, and an assumed horizontal load. The minimum total design load for any falsework shall be not less than 100 pounds per square foot for the combined live and dead load regardless of slab thickness.

Dead loads shall include the weight of concrete, reinforcing steel, forms and falsework. The weight of concrete, reinforcing steel and forms shall be assumed to be not less than 160 pounds per cubic foot for normal concrete and not less than 130 pounds per cubic foot for lightweight concrete.

Live loads shall consist of the actual weight of any equipment to be supported by falsework applied as concentrated loads at the points of contact and a uniform load of not less than 50 pounds per square foot applied over the area supported.

The assumed horizontal load to be resisted by the falsework bracing system shall be the sum of the actual horizontal loads due to equipment, construction sequence or other causes and an allowance for wind, but in no case shall the assumed horizontal load to be resisted in any direction be less than two percent of the total dead load. The falsework shall be designed so that it will have sufficient rigidity to resist the assumed horizontal load without considering the weight of the concrete.

If the concrete is to be prestressed, the falsework shall be designed to support any increased or readjusted loads caused by prestressing forces.

Falsework shall be designed by the working stress design method, and stresses under all loads shall not exceed the maximum allowable stresses provided for in the current edition of AASHTO Standard Specifications for Highway Bridges. The maximum allowable stresses

provided for in the National Design Specification for wood construction (NDS) may be used as an alternate to the AASHTO specifications for timber design. The maximum allowable horizontal shear stress in timber shall not exceed 125 pounds per square inch after all applicable modification factors have been applied. No increase in allowable stresses for repetitive member uses will be allowed.

Unless otherwise specified on the plans, deflection of the falsework span due to the weight of concrete only shall not exceed 1/240 of the falsework beam span irrespective of the fact that the deflection may be compensated for by camber strips.

In the case of post-tensioned structures, the falsework deflections shall not produce stresses in the structure at any time prior to post-tensioning greater than 0.8 times the modulus of rupture for plain concrete unless approved by the Engineer.

Falsework over or adjacent to roadways or railroads which are open to traffic shall be designed and constructed so that the falsework will be stable if subjected to impact by vehicles. Falsework posts which support members that cross over a roadway or railroad shall be considered as adjacent to roadways or railroads. Other falsework posts shall be considered as adjacent to roadways or railroads only if they are located in the row of falsework posts nearest to the roadway or railroad and the horizontal distance from the traffic side of the falsework to the edge of pavement or to a point 10 feet from the centerline of track is less than the total height of the falsework and forms.

The vertical load used for the design of falsework posts and towers, but not footings, which support the portion of the falsework over openings, shall be increased to not less than 150 percent of the design load calculated in accordance with the provisions for design load previously specified.

Falsework posts adjacent to roadways or railroads shall consist of either steel with a minimum section modulus about each axis of 9.5 inches cubed or sound timbers with a minimum section modulus about each axis of 250 inches cubed.

Each falsework post adjacent to roadways or railroads shall be mechanically connected to its supporting footing at its base, or otherwise laterally restrained, so as to withstand a force of not less than 2,000 pounds applied at the base of the post in any direction except toward the roadway or railroad track. Such posts also shall be mechanically connected to the falsework cap or stringer. Such mechanical connection shall be capable of resisting a load in any horizontal direction of not less than 1,000 pounds.

For falsework spans over roadways, all exterior falsework stringers and stringers adjacent to the ends of discontinuous caps, the stringer or stringers over points of minimum vertical clearance and every fifth remaining stringer, shall be mechanically connected to the falsework cap or framing. Such mechanical connections shall be capable of resisting a load in any direction, including uplift on the stringer, of not less than 500 pounds. Such connections shall be installed before traffic is allowed to pass beneath the span. For falsework spans over railroads, all falsework stringers shall be so connected to caps.

When timber members are used to brace falsework bents which are located adjacent to roadways or railroads, all connections for such timber bracing shall be of the bolted type using 5/8 inch diameter or larger bolts, or shall be connected in a manner that will equal 100 percent capacity of the smaller member connected.

The falsework shall be located so that falsework footings or piles are at least three inches clear of railing posts and barriers and all other falsework members are at least one foot clear of railing members and barriers.

Falsework bents within 20 feet of the center line of a railroad track shall be sheathed solid in the area between 3 and 17 feet above the track elevation on the side facing the track. Sheathing shall consist of plywood not less than 5/8 inch thick or lumber not less than one inch thick (nominal). Bracing on such bents shall be adequate so that the bent will resist the required assumed horizontal force or 5,000 pounds, whichever is greater.

Drawings shall be prepared in accordance with the requirements of Subsection 105.03.

The drawings shall be complete and fully detailed working drawings showing the dimensions and material for all parts, arrangement, spacing, and connections, and all provisions for adjustment and for measuring displacement. The falsework foundations, any connections or contacts with previously built structures or other works, and the means of protecting such other works from damage shall be detailed. The above data may be presented as convenient either on the drawings or in the design summary, which shall also describe the assumptions and types of calculations used in the design and the stresses and deflections found for critical points. For any embankments used, the equivalent of the above drawings and data shall be submitted, and in addition the source, classification, and compaction requirements for the material and the results of any tests performed on the material. In no case shall the embankment be compacted to less than 90 percent compaction, and the top three feet shall be compacted to a minimum of 95 percent compaction when tested in accordance with the requirements of the applicable test methods of the ADOT Materials Testing Manual, as directed and approved by the Engineer. The embankment shall be topped with a lean concrete waste slab screeded to the required grades.

Falsework design will require written approval by the Engineer prior to commencing work and shall be in accordance with the requirements of Subsection 105.03.

Except as provided for on the project plans, supports for deck falsework, forming or screed supports shall not be welded to steel girders, shear connectors, slab ties or girder stirrups.

Modification of girders to support falsework and forming will not be allowed except as approved by the Engineer. This includes connections of any type in girder webs to support deck forming. When modification of girders to support the deck falsework and forming has been approved by the Engineer, shop drawings for both the girders and the falsework and forming shall be submitted concurrently so that the review and approval of the drawings can be coordinated.

The tops of the erected girders shall be surveyed by the contractor in the field prior to placement of the deck forming falsework. This survey shall be submitted to the Engineer for

evaluation. If the top of erected girder elevations are higher than the screed elevations minus the combined deck slab and the buildup thicknesses, adjustments will have to be made in the roadway profile or in the girder bearing seat elevations. Encroachment into the deck slab of up to 1/2 inch will be allowed for random occurrences.

(B) Falsework Construction:

The falsework shall be constructed to conform to the falsework drawings. The materials used in the falsework construction shall be of the quality necessary to sustain the stresses required by the falsework design. The workmanship used in falsework construction shall be of such quality that the falsework will support the loads imposed on the falsework.

Falsework shall be founded on a solid footing safe against undermining and capable of supporting the loads imposed.

No concrete shall be placed in any forms supported by falsework until the contractor's professional engineer has inspected the completed falsework and has issued a properly signed and sealed certificate that the falsework has been constructed according to the approved falsework drawings.

Wedges, screws or jacks shall be used in connection with falsework to set the forms to required grade and uniform bearing prior to placing concrete.

All wedges shall be in pairs to insure uniform bearing. Laminated sections will not be permitted. If additional material is required under wedges, either single blocks or thicker wedges will be required. A sufficient number of wedges shall be used to cover the entire bearing area.

The contractor shall provide tell-tales attached to the soffit forms and readable from the ground in enough systematically placed locations to determine the total settlement of the entire portion of the structure where concrete is being placed.

If any weakness develops during the placing of the concrete or the falsework shows any undue settlement or distortion, the work shall be stopped and the falsework corrected and strengthened.

(C) Forms Construction:

(1) General Requirements:

Forms shall be of wood, metal or other suitable material conforming to the requirements specified herein. Forming plans for cast-in-place bridge girders shall be prepared in accordance with the requirements of Subsection 105.03.

The forms shall be mortar tight and shall be designed, constructed, braced and maintained so that the finished concrete will be true to line and elevation and will conform to the required dimensions and contours. They shall be designed to withstand the pressure of concrete with consideration given to rate of concrete placement, temperature of the concrete, use of

set-retarding admixtures or pozzolanic materials in the concrete, the effects of vibration as the concrete is being placed and all loads incidental to the construction operations, without distortion or displacement.

Stay-in-place forming shall not be used unless specified on the plans or approved by the Engineer. Expanded metal meshes may be used to form construction joints providing:

(a) Three-inch edge cover is maintained, and

(b) Use in bridge decks is prohibited.

Forms reused shall be maintained at all times in good condition as to accuracy of shape, strength, rigidity, watertightness and smoothness of surface. Forms or form lumber unsatisfactory in any respect shall not be used.

Forms shall be constructed so that portions may be removed without disturbing forms that are to remain. Forms to be used when a Class II finish or ornamental work is required shall be constructed of metal, fiberglass coated panels, or plywood. All form joints shall be taped or caulked in an acceptable manner. Forms for this work shall be equivalent to first class pattern work.

Forms shall be filleted 3/4 inch at all exposed, sharp corners of the concrete.

All forms shall be treated with an approved form release agent before concrete is placed. Any material which will adhere to or discolor the concrete shall not be used.

Forms shall be cleaned of all dirt, sawdust, water and other foreign material prior to placing concrete in the forms.

For narrow walls and columns where the bottom of the form is inaccessible, provisions shall be made for cleaning out extraneous material immediately before placing the concrete. The cells of box girders shall be cleared of all loose materials prior to the completion of deck forming when such forming is to remain in place. When the deck forming is to be removed, the cells of the box girders shall be cleared of all loose materials after removal of the forms.

(2) Wood Forms:

All lumber used for forms shall be free from defects affecting the accuracy of shape, strength, rigidity, watertightness and smoothness of the surface. All lumber for forms above stream bed shall be plywood. All form lumber shall be securely fastened to the studding so that cupping cannot occur. Chamfer strips shall be of selected material dressed to true line and uniform dimensions. The interior surfaces of all forms in contact with concrete surfaces which will be exposed in the finished work shall be smooth and even. No uneven or offset joints or single boards projecting so that their impressions are left in the concrete will be allowed. Forms, as far as practicable, shall be so constructed that the form marks will conform to the general lines of the structure. In general, grain of the lumber and direction of side joints shall be horizontal on wide faces and walls and vertical on narrow faces. If varying widths of panels are used, the wider panels shall be placed on the bottom and the narrower

ones near the top. Panel end joints shall be staggered not less than three feet. Spreaders made of wood shall not be left in the concrete.

(3) Metal, Fiberglass and Other Forms:

The same provisions as specified under wood forms shall apply to metal and fiberglass forms and in addition, the following shall apply:

All bolts and rivet heads shall be countersunk. Clamps, rods, pins or other connecting devices shall be designed to hold the forms rigidly together and allow removal without injury to the concrete. Forms which do not present a smooth surface or are not properly aligned shall not be used.

Care shall be exercised to keep the forms free of dust, grease or other foreign matter which will tend to discolor the concrete.

Metal forms shall be used for the casting of precast I-beams, box beams, and voided or flat slabs where the contract number of units combined dictates production runs equal to or longer than the precasting bed length. A limited number of units, having a total combined length at least one unit length less than bed length, may be cast with alternate forms, as approved by the Engineer. Dimensional tolerances using alternate forms shall conform with Subsection 601-4.02(B).

Waste slabs used as a part of the forms shall be finished to the appropriate grade including any camber. The finished slab shall not vary more than 1/4 inch from the theoretical grade nor more than 1/4 inch from a 10 foot straightedge in any direction.

(4) Internal Cells:

Internal cells or voids in pre-cast box beams shall be constructed with either wood forms conforming to Subsection 601-3.02(C)(2), or with expanded polystyrene having exterior surfaces faced with hardboard. Expanded polystyrene shall be commercially available polystyrene board. Hardboard shall be 1/8 inch minimum thickness conforming to ANSI/AHA (American Hardboard Association) Standard A 135.4, any type listed. As an alternative to hardboard, other facing materials may be used provided the polystyrene is equally protected. Internal cells shall be completely sealed so no plastic concrete is allowed to enter the formed cell. All wood and polystyrene/hardboard sections shall be securely held in place by either nails, waterproof adhesive, or other means approved by the Engineer.

(D) Removal of Falsework and Forms:

No falsework or forms shall be relieved of load and no forms shall be removed without approval of the Engineer.

Falsework, excluding bridge deck cantilevered overhangs for cast-in-place prestressed structures, shall not be removed until after the prestressing steel has been tensioned and a minimum of 72 hours after the prestressing steel has been grouted. Falsework for the cantilevered bridge deck overhang shall be removed prior to prestressing but shall not be

removed within seven days of concrete placement unless the concrete has attained a minimum compressive strength of 3,000 pounds per square inch. In no case shall falsework be removed within five days of concrete placement. On bridges with both transverse and longitudinal stressing, the deck or overhang falsework shall not be removed until after the transverse prestressing has been completed unless shown otherwise on the plans. The deck overhang falsework shall then be removed prior to performing the longitudinal prestressing.

Falsework for cast-in-place non-prestressed structures or composite superstructures, excluding concrete above the bridge deck, shall not be removed until either:

(1) At least 10 days after the last concrete has been placed in each continuous span and until the compressive strength of all placed concrete has attained at least 70 percent of the required 28-day compressive strength; or

(2) At least five days after the last concrete has been placed in each continuous span and until the concrete has attained the required 28-day compressive strength.

The sloped exterior girders of cast-in-place box girder bridges shall be laterally braced or supported until the top slab (deck) concrete has been placed and has attained at least 70 percent of the required 28-day compressive strength.

Side forms for footings, beams, girders, box culverts, columns, railings, curbs or other members wherein the forms do not resist dead load bending may be removed after the concrete has set, and the contractor shall cure and protect the concrete thus exposed in accordance with the requirements of Section 1006. The contractor shall assume all risks and responsibility resulting from such removals. Forms for cast-in-place concrete, unless otherwise specified herein, shall not be removed until at least seven days after concrete has been placed in the forms, without the approval of the Engineer.

Placement of backfill material shall be in accordance with Subsection 203-5.03(B). Where backfill is to be placed against both sides of a structural element, the backfill elevations on one side of the element shall not exceed the backfill elevations on the opposite side of the element by more than five feet.

Forms for precast concrete shall stay in place a minimum of eight hours.

The period of time between the placement of concrete in the top slab of a standard concrete box culvert (12 foot span or less) and the removal of the slab support forms may be reduced to 48 hours if the top slab remains supported along the center line of the culvert span by a continuous beam and line of posts erected as a part of the original slab form, and which will remain in place, undisturbed, a minimum of seven days.

If the Engineer allows the removal of forms before the specified curing period has elapsed, the contractor shall cure the concrete for the remaining required curing time by one of the methods specified in Section 1006.

Forms for cast-in-place concrete above the bridge decks that require a Class II finish may be removed after the concrete has set, providing the required surface finishing of the concrete is completed within four days. If finishing cannot be completed within four days, the forms shall remain in place for seven days.

All forms shall be removed, except forms used to support the deck of box girders when no permanent access to the cells is available.

Care shall be taken in removing falsework and forms so as not to deface or damage the structure. Methods of removal likely to damage or cause overstressing of the concrete shall not be used.

All falsework shall be removed from under bridge superstructures prior to opening the structure to traffic. Falsework shall be removed in such a manner that excessive stresses are not induced into the structure. Holes shall not be drilled into the structure to facilitate removal of the falsework. Round blockouts may be used for such purpose providing the contractor can submit evidence that the blockouts are not detrimental to the structure and the Engineer approves the use of the blockouts. The maximum blockout diameter shall not exceed six inches.

601-3.03 Placing Concrete:

(A) General Requirements:

No concrete shall be placed in any structure until the placement of reinforcing steel and the adequacy of the forms and falsework have been approved by the Engineer.

Adequate time shall be given to the Engineer to check all form dimensions, embedded items, and placement of reinforcing steel. Concrete shall not be placed until all necessary corrections have been made by the contractor and all work required for the proposed pour has been completed.

Reinforcing steel shall be placed in accordance with the requirements of Section 605 and the plans.

The sequence of concrete placement shall be as shown on the project plans or as approved by the Engineer when not shown on the project plans.

Concrete shall be placed and consolidated by methods that will not cause harmful segregation and will result in a dense homogeneous concrete free of honeycomb or voids.

Concrete shall be placed in horizontal layers not over 24 inches in depth unless otherwise approved by the Engineer.

Concrete shall be placed as nearly as possible in its final position and the use of vibrators for shifting the mass of fresh concrete will not be permitted. Dropping the concrete more than eight feet without the use of approved pipes or tubes will not be allowed.

Care shall be taken to fill all areas within the forms and to force the concrete under and around the reinforcement without displacing the reinforcement or other embedded items.

Conveying equipment shall be capable of providing a supply of concrete to the point of placement without segregation, or interruptions sufficient to permit loss of plasticity between successive increments.

Concrete placed in slabs and floors other than bridge decks shall be struck off by means of a screed. The screed may be self-propelled screed equipment or the type specified under Subsection 401-3.04(D), Fixed Form-Manual Methods.

No concrete that has partially hardened or been contaminated by foreign materials shall be deposited in the structure.

The rate of concrete placement and consolidation shall be such that the formation of cold joints within monolithic sections of any structure will not occur. Any portion of any structure displaying apparent cold joints will be rejected, unless the contractor, at no additional cost to the Department, can submit evidence that will indicate that either a cold joint does not exist or that a cold joint is not detrimental to the structure. The Engineer shall be the sole judge in determining the existence of a cold joint and whether its existence is detrimental to the structure. The rate of concrete placement for major structures shall not be less than 35 cubic yards per hour unless otherwise specified or approved in writing by the Engineer. This rate shall not apply to precast concrete members.

The rate of concrete placement for the bottom slabs and girder walls of cast-in-place box girder superstructures shall not be less than 60 cubic yards per hour when the volume of concrete to be placed exceeds 300 cubic yards.

(B) Bridge Deck:

The placing of concrete will not be permitted until the Engineer is satisfied that the rate of producing and placing concrete shall be sufficient to complete the proposed pour and finishing operations within the scheduled time, that experienced concrete finishers are available to finish the deck and that all necessary finishing tools and equipment are on hand at the site of the work and are in satisfactory condition for use.

Concrete shall be placed for the full width of the panel to be poured. After the concrete has been placed it shall be consolidated and then struck off by means of self-propelled screed equipment.

Screed equipment shall be designed to operate as close as practicable to bridge curbs or other obstructions.

Screed equipment shall travel on steel rails. Rails shall be substantially supported by adjustable steel supports of adequate size securely fastened in place and spaced at sufficiently close intervals to prevent any appreciable deflection in the rails. Steel supports shall be of such types and installed in such manner that when the rail and adjustable support have been removed, there will be no void in the concrete.

The steel rails for placing and finishing equipment shall be set to the correct elevation shown on the project plans or as established by the Engineer. The rails shall extend beyond both ends of the scheduled length for placement a sufficient distance that will permit the screed and finishing equipment to reach all areas of the concrete placed.

Placement of the deck concrete shall be in accordance with the placing sequence shown on the project plans. The contractor shall submit a drawing showing the placement sequence construction joint locations, directions of the concrete placement and any other pertinent data to the Engineer for review. The drawing shall be submitted at least four weeks prior to the date of deck placement.

Screed beams or rollers shall be made of metal, or the bottom of the beam shall be metal clad. Roller screeds shall be constructed so that there will be no sag or deflection in the screeds.

Screed assemblies shall be equipped with vibrators. The screed assemblies shall be so designed that the vibrating units do not contact any reinforcing steel. Vibration shall be transmitted to the concrete in such a manner that when the motion of the machine is stopped, all vibration will cease.

A slight excess of concrete shall be maintained in front of the screed at all times during the screeding operation. The screed shall make as many passes over the slab as may be necessary to obtain a uniform surface.

The contractor shall furnish a minimum of two transverse work bridges from which floating, straightedging, and curing operations may be accomplished. The work bridges shall be reasonably rigid and free of excessive deflections. The self-propelled mechanical bridge used for texturing the bridge deck may be substituted for one of the required work bridges.

The floating operation shall follow the screeding if required. The float shall have a minimum diameter of three inches and have a minimum length of 12 feet. The float shall be constructed so that the surface will be maintained true at all times.

Prior to placing concrete, the screed shall be traversed the length of the proposed pour and the clearance from the screed to the reinforcing steel and deck thickness shall be checked. The method of determining the clearance shall be approved by the Engineer prior to making such checks. The clearance shall be as indicated on the project plans with a permissible variation of ± 1/4 inch. Deflection of the screed rails as a result of the weight of the screed equipment will not be permitted. All corrections necessary as a result of this operation shall be performed prior to beginning the pour.

(C) Pumping Concrete:

Where concrete is conveyed and placed by mechanically applied pressure, the equipment shall be of suitable type and shall have adequate capacity for the work. The concrete shall not flow either over or through any piping, fittings or equipment which is fabricated of aluminum or aluminum alloys. The operation of the pump shall be such that a continuous

stream of concrete without air pockets is produced. Excessive segregation due to high velocity discharge of the concrete will not be permitted. When pumping is completed, the concrete remaining in the pipeline, if it is to be used, shall be ejected in such a manner that there will be no contamination of the concrete or segregation of the ingredients. Standby equipment shall be readily available to replace initial pumping equipment should breakdown occur.

(D) Vibrating Concrete:

All concrete in structures shall be consolidated by means of approved vibrators together with any other equipment necessary to perform the work as specified herein. The minimum frequency of the internal vibrators shall be 8,000 vibration cycles per minute.

Vibration shall be applied in the area of the freshly deposited concrete. Vibrators shall penetrate to the bottom of the concrete layer and at least six inches into the preceding layer. The vibration shall be of sufficient duration and intensity to consolidate the concrete thoroughly within 15 minutes after it has been deposited in the forms.

Vibration shall not be continued at any one point to the extent that localized areas of grout are formed. Application of vibrators shall be at points uniformly spaced and not farther apart than twice the radius over which the vibration is visibly effective.

Re-vibration of concrete may be required at any time as directed by the Engineer.

The contractor shall provide sufficient equipment to insure uninterrupted and continuous vibration of concrete.

(E) Placing Concrete in Water (Tremie Concrete):

Tremie concrete shall be deposited in water only if either specified on the project plans or when directed and then only under the Engineer's supervision. When depositing in water is allowed, the concrete shall be carefully placed in a compact mass in the space in which it is to remain by means of a tremie, bottom dump bucket or other approved method that does not permit the concrete to fall through the water without adequate protection. The concrete shall not be disturbed after being deposited. No concrete shall be placed in running water and forms which are not reasonably watertight shall not be used for holding concrete deposited under water.

A head of concrete shall remain above the discharge end of the tremie tube at all times.

(F) Bridge Deck Widening:

Where the roadway portion of a bridge deck widening section is more than 12 feet in width, concrete shall be placed in the roadway portion in accordance with the requirements of Subsection 601-3.03(B).

Where the roadway portion of a bridge deck widening section is 12 feet or less in width, the spreading and floating of concrete in the roadway portion shall conform to the requirements of Subsection 401-3.04(D).

(G) Pedestrian Rail and Fence:

This work shall consist of furnishing and constructing Traffic and Pedestrian Rail, Pedestrian Fence and Curb, Pedestrian Fence and Parapet, and Fence and Parapet, including all hardware and materials, in accordance with the requirements of the project plans.

(H) Bridge Barriers and Transitions:

This work shall consist of furnishing and constructing Bridge Concrete Barriers and Bridge Concrete Barrier Transitions, including all hardware and materials, in accordance with the requirements of the project plans.

(I) Approach and Anchor Slabs:

This work shall consist of furnishing and constructing reinforced concrete approach and anchor slabs for bridges, including all tools, equipment, labor, and materials. All work shall be in accordance with the details shown on the project plans and the requirements of these specifications.

601-3.04 Joints in Major Structures:

(A) Construction Joints:

Except as otherwise specified herein, construction joints shall be constructed at the locations specified on the project plans.

Construction joints shall be placed in the locations shown on the project plans or as approved by the Engineer. Except under emergency conditions, construction joints shall be planned and located in advance of placing concrete. All construction joints shall be perpendicular to the principal lines of stress and in general located at points of minimum shear and moment.

Construction joints shall be constructed in accordance with the details shown on the project plans or as directed by the Engineer. Before new concrete is placed against concrete which has hardened, forms shall be drawn tight against the face of the concrete, wood keys shall be removed and the exposed steel or dowels and the entire surface of the construction joint shall be thoroughly cleaned. Immediately ahead of placing fresh concrete on the construction joint, the old concrete shall be thoroughly saturated with water.

After placing of concrete has been completed to the construction joint and before placing fresh concrete, the exposed reinforcing steel and the entire surface of the construction joint shall be thoroughly cleaned of surface laitance, curing compound and other materials foreign to the concrete and clean, coarse aggregate exposed. Surfaces of concrete that have been in place for eight hours or more shall be cleaned by abrasive blast methods. Surfaces of

concrete that have been in place for less than eight hours may be cleaned with air and water jets provided that surface laitance and curing compound is removed.

After the concrete surfaces have been treated as specified, they shall be cleaned of all dust and abrasive material.

(B) Deck Joint Assemblies:

(1) Description:

This work shall consist of furnishing and installing expansion devices including the seals, anchorage system and hardware in conformity with the project plans and the requirements of these specifications.

(2) Materials:

Elastomer seals shall be of the Compression Seal or Strip Seal type and shall conform to the requirements of Subsection 1011-5.

Steel shapes and plates shall conform to the requirements of ASTM A 36 or A 588.

(3) Construction Requirements:

(a) General:

Deck joint assemblies shall consist of elastomer and metal assemblies which are anchored to the concrete at the joint. The seal armor shall be cast in the concrete. The completed assembly shall be in planned position, shall satisfactorily resist the intrusion of foreign material and water and shall provide bump-free passage of traffic.

For each size of seal on a project, one piece of the material supplied shall be at least 18 inches longer than required by the project plans. The additional length will be removed by the Engineer and used for testing by ADOT Materials Group. Certificates of Compliance conforming to the requirements of Subsection 106.05 shall be submitted.

(b) Shop Drawings:

Prior to fabrication, the contractor shall submit eight sets of shop drawings to the Engineer for approval in accordance with the requirements of Subsection 105.03. The shop drawings shall show complete details of the method of installation to be followed, including a temperature correction chart for adjusting the dimensions of the joint according to the ambient temperature and any additions or rearrangements of the reinforcing steel from that shown on the project plans.

Deck joint assemblies for prestressed concrete structures shall be installed at the narrowest joint opening possible to allow for long term creep.

(c) Elastomer Seals:

Seals shall conform to the requirements hereinbefore specified.

(d) Welding:

All welding shall be in accordance with the requirements of Subsection 604-3.06.

(e) Armor:

All metal for cast-in-place seal assemblies shall be steel conforming to the requirements hereinbefore specified.

(f) Galvanizing:

All metal parts of strip seal assemblies shall be galvanized after fabrication in accordance with the requirements of ASTM A 123 and A 153, unless ASTM A 588 steel is used. Bolts shall be high strength, conforming to the requirements of ASTM A 325, with a protective coating of cadmium or zinc followed by a chromate and baked organic coating according to ASTM F 1135, Grade 3, 5, 6, 7 or 8 and Color Code A.

Metal parts of compression seal assemblies do not require galvanizing, plating, or painting.

(g) Joint Preparation and Installation:

The contractor shall form the joint with a secondary concrete pour. The surface of the existing concrete shall be coated prior to the concrete being placed with an approved adhesive specifically formulated for bonding new concrete to old concrete.

Joints to be sealed shall be covered or otherwise protected at all times prior to installing the elastomer portion of the assembly. The elastomer shall be installed at such time and in such manner that it will not be damaged by construction operations.

The seal element shall be installed subject to these specifications and the approval of the Engineer. Immediately prior to the installation of the seal element, the metal contact surfaces of the joint armor shall be clean, dry and free of oil, rust, paint or foreign material. Any perforation or tearing of the seal element due to installation procedures or construction activities will be cause for rejection of the installed seal element.

(C) Water Stops:

Water stops of rubber or plastic, shall be placed in accordance with the details shown on the project plans. Where movement at the joint is provided for, the water stops shall be of a type permitting such movement without injury. They shall be spliced, welded or soldered, to form continuous watertight joints.

(D) Joints in Deck Units:

After erection and at the time directed by the Engineer, the longitudinal joints or shear keys shall be thoroughly packed with a pre-packaged nonshrink grout or a sand-cement grout with an expansion agent approved by the Engineer. The contractor shall then transversely connect the deck units with the connection rods, stressing and anchoring them as shown on the project plans.

601-3.05 Finishing Concrete:

(A) General Requirements:

The appropriate finish, as specified herein, shall be applied to each surface of all concrete structures.

All formed surfaces will require a Class I Finish. Formed surfaces shall be finished immediately after the removal of forms in accordance with the requirements specified herein. If rock pockets or honeycomb are of such an extent and character as to affect the strength of the structure and to endanger the steel reinforcement, the Engineer may declare the concrete defective and require the removal and replacement of that portion of the structure affected at the expense of the contractor.

Formed surfaces normally in view of vehicular or pedestrian traffic, or not covered by fill material shall present a pleasing appearance of uniform color and texture commonly achieved by the use of clean, smooth plywood forms joined tightly or taped at the joints, preformed metal forms, paper tubing forms, or specially-coated forms. If a pleasing appearance has not been achieved, either in the formed surface or at the joints, the Engineer will order that the surface be finished in accordance with the requirements for a Class II Finish.

(B) Class I Finish:

All bolts, wires, snap-ties, and rods shall be clipped and recessed one inch below the surface of the concrete. All holes, honeycomb, rock pockets and other surface imperfections shall be cleaned to sound concrete, thoroughly moistened and carefully patched with mortar.

Mortar shall be composed of one part cement, two parts of fine sand, water and an adhesive of a type approved by the Engineer. A portion of the required cement shall be white as required to match the color of the surrounding concrete. Small voids due to entrapped air and water in precast members need not be patched.

(C) Class II Finish:

The surface shall be patched and pointed as specified herein for Class I finish. When the mortar used in patching and pointing has set sufficiently, the surface shall be rubbed with cork, wood, or rubber floats, polystyrene, or a mechanical carborundum stone. During the rubbing process a thin mortar, matching the color of surrounding concrete, may be used to facilitate producing a satisfactory lather. The mortar used to produce a lather shall not be used in quantities sufficient to cause a plaster coating to be left on the finished surface. Rubbing shall continue until irregularities are removed and there is no excess material. At

the time a light dust appears, the surface shall be brushed or sacked. Brushing or sacking shall be carried in one direction so as to produce a uniform texture and color.

(D) Finishing Bridge Deck:

When specified on the project plans, bridge decks that will be covered with a special riding surface, or waterproofing membrane, shall not be textured and shall be finished to a smooth floated surface free of mortar ridges, hollows, and any other projections prior to curing.

The finishing operation shall be completed before the water sheen disappears. Water shall not be applied to the deck surface at any time during floating or finishing except that a fog spray may be applied.

Fogging equipment shall be capable of applying water to the concrete in form of a fine fog mist in sufficient quantity to curb the effects of rapid evaporation of mixing water from the concrete.

The finished surface of the concrete shall be tested with a 10 foot straightedge placed on the deck surface. The surface plane shall not vary by more than 1/8 inch, as measured from the bottom of the straightedge, on deck surfaces exposed directly to traffic. Deck surfaces to be covered with a special riding surface or waterproofing membrane shall not vary by more than 1/4 inch as measured from the bottom of the straightedge.

Areas showing deviations greater than those specified shall be corrected in a manner approved by the Engineer. All corrected areas shall be textured to match the finish of the surrounding deck surface.

Where the surface will be exposed directly to traffic, it shall be textured transversely, after final floating in the plastic concrete or after the completion of the curing period to produce a uniformly grooved surface. Widened bridge decks shall be finished to match the existing deck surface texture.

The apparatus producing the textured grooves in the plastic concrete shall be mechanically operated from an independent self-propelled bridge. The bridge shall be used for texturing only and shall be supported on the same steel rails used for the screed equipment.

The timing of the texturing operation in the plastic concrete is critical. The texturing shall be completed before the surface is torn or unduly roughened by the texturing operation. Grooves that close following the texturing will not be permitted.

Hand tine brooms shall be provided and available at the job site at all times when texturing plastic concrete.

Bridge sidewalks shall be finished to a light broomed texture.

601-3.06 Curing Concrete:

Curing cast-in-place concrete and curing precast concrete members shall be in accordance with the requirements of Subsection 1006-6.

601-3.07 Supporting, Handling, and Transporting Precast Concrete Items:

After prestressing, precast members for major structures shall be handled or supported at or near the final bearing points for storage.

Precast items shall be supported during transporting in a manner that will allow reasonable conformity to the proper bearing points. At all times, the items shall be handled or supported securely in an upright position.

Items that have been damaged in shipment will be rejected at the point of delivery.

Lifting devices shall not project above the surface of the item after placement unless they will be embedded in a subsequent concrete pour, will have a minimum concrete cover of two inches, and will not interfere with the placement of reinforcing steel or concrete.

601-3.08 Backfilling:

Structure backfill shall be placed in accordance with the requirements of Subsection 203-5.03(B).

601-3.09 Vertical Restrainers:

(A) Description:

The contractor shall furnish and install restrainer units consisting of cables and assemblies and associated materials or components in conformance with the details shown on the project plans, and in accordance with these specifications.

Components required for each restrainer unit type will be detailed on the project plans and shall include various combinations of the following: cables, clips, No. 11 rebar, duct tape, expanded polystyrene, hardboard, and incidentals.

(B) Materials:

Cables shall be 3/4 inch diameter preformed, 6 by 19 wire strand core, or independent wire rope core (IWRC), galvanized ASTM A 603 Class A coating, right regular lay, manufactured of improved plow steel with a minimum breaking strength of 21 tons. Two certified copies of mill test reports of each manufactured lengths of cable used shall be furnished to the Engineer.

Free ends of cable restrainer units shall be securely wrapped at each end to prevent separation.

The cable assemblies shall be shipped as a complete unit.

A minimum of one test loop assembly per bridge or one test loop assembly for every 40 cable assemblies, which ever is greater, shall be furnished to the Engineer for testing. The test loop assembly shall be fabricated from the same lot of material, wire rope and fittings or clips as the cable assemblies. The test loop assembly shall be not less than 27 inches or more than 33 inches long when pulled taut.

Tempered hardboard shall conform to Federal Specification LLL-B-810, Type II, smooth one side, plain. Hardboard shall be 1/8 inch minimum thickness, unless shown or specified otherwise.

Expanded polystyrene shall be a commercially available polystyrene board. Expanded polystyrene shall have a flexural strength of 35 pounds per square inch minimum determined in accordance with ASTM C 203, and a compressive yield strength of between 16 and 40 pounds per square inch, at five percent compression. When shown on the plans, surfaces of expanded polystyrene shall be faced with hardboard.

Other facing materials may be used provided they furnish equivalent protection. All boards shall be held in place by nails, waterproof adhesive, or other means approved by the Engineer.

(C) Construction Requirements:

Restrainers shall be installed as indicated on the project plans.

The contractor shall provide means of holding the cable assemblies in their planned positions.

The contractor shall be responsible for determining the required length of the cable assemblies.

601-4 Tests on Finished Structures:

601-4.01 Surface Texture:

The grooves for decks exposed directly to traffic shall be 1/16 to 1/8 inch in width and 3/32 to 6/32 inch in depth. The textured groove depth will be measured in accordance with the requirements of Arizona Test Method 310. The center spacing of the grooves shall be 1/2 to one inch.

601-4.02 Dimensional Tolerances:

(A) Cast-in-Place Concrete:

The maximum allowable tolerances or deviations from dimensions shown on the project plans or the approved shop drawings shall be as follows:

(1) Variation from plumb in the lines and surfaces of columns, piers, abutment and girder walls:

In any 10-foot-or-less length: 3/8 inch
Maximum for the entire length: 1 inch

(2) Variation in cross-sectional dimensions of columns, piers, girders, and in the thickness of slabs and walls:

+ 1/4 inch
- 1/8 inch

(3) Girders alignment (deviation from straight line parallel to center line of girder measured between diaphragms):

1/8 inch per every 10 feet in length

(4) Variation in footing cross sectional dimensions in project plans:

+ 2 inches
- 1/2 inch

(5) Variation in footing thickness:

*Greater than specified: No Limit

Less than specified: 5 percent of specified thickness up to a maximum of one inch

*Does not apply to reinforcing steel placement.

(6) Subgrade Tolerances:

Slab poured on subgrade excepting footing thickness:

+ 1/4 inch
- 3/4 inch

(7) Girder Bearing Seats:

Deviation from plane surface (flatness):

± 1/8 inch in ten feet.

Deviation from required elevation:

- 1/4 inch
+ 1/8 inch

(8) Cast-In-Place concrete box girder superstructures:

Deviation in overall depth:

+ 1/4 inch
- 1/8 inch

Deviation in slab and wall thickness:

+ 1/4 inch
- 1/8 inch

Deviation of post-tensioning ducts:

± 1/4 inch

(B) Precast Concrete Structures:

(1) General:

Precast units that do not comply with the dimensional tolerances specified herein will be rejected. Precast units that show evidence of cracks, pop outs, voids or other evidence of structural inadequacy or imperfections that will reduce the aesthetics of the unit after final placement will be rejected.

(2) Precast Concrete I-Beams:

The maximum allowable tolerances of deviations from dimensions and details shown on the project plans or the approved shop drawings shall be as follows:

(a) Length: ± 3/4 inch

(b) Width (flanges and fillets): + 3/8 inch, - 1/4 inch

(c) Depth (overall): + 1/2 inch, - 1/4 inch

(d) Width (web): + 3/8 inch, - 1/4 inch

(e) Depth (flanges and fillets): ± 1/4 inch

(f) Bearing plates (ctr. to ctr.): ± 1/8 inch per 10, but not greater than ± 3/4 inch

(g) Horizontal alignment (deviation from straight line parallel to center-line of member): 1/8 inch per every 10 feet in length

(h) Stirrup bars (deviation from top of beam): + 1/4 inch
- 3/4 inch

(i) Tendon position: ± 1/4 inch c.g. of strand group and individual strands

(j) Horizontal position of deflection points for deflected strands: ± 10 inches

(k) Position of handling devices: ± 6 inches

(l) Bearing plates (ctr. to end of beam): ± 1/4 inch

(m) Side inserts (ctr. to ctr. and ctr. to end): ± 1/2 inch

(n) Exposed beam ends (deviation from square or designated skew):

Horizontal: ± 1/4 inch

Vertical: ± 1/8 inch per foot of beam depth

(o) Bearing area deviation from plane: ± 1/8 inch

(p) Stirrup bars (longitudinal spacing): ±1 inch

(q) Position of post-tensioning duct: ±1/4 inch

(r) Position of weld plates: ± 1 inch

(3) Precast Concrete Box Beams and Flat Slabs:

The maximum allowable tolerances or deviations from dimensions and details shown on the project plans or the approved shop drawings shall be as follows:

(a) Length: ± 3/4 inch

(b) Width (over-all): ± 1/4 inch

(c) Depth (over-all): ± 1/4 inch

(d) Width (web): ± 3/8 inch

(e) Depth (top slab): ± 1/4 inch

(f) Depth (bottom slab): + 1/4 inch, - 1/8 inch

(g) Horizontal alignment (deviation from straight line parallel to center line of member): 1/8 inch per every 10 in length

(h) Camber differential between adjacent units:

Not greater than 3/4 inch

(i) Position of tendons: ± 1/4 inch c.g. of strand group

(j) Longitudinal spacing of stirrup bars: ± one inch

(k) Position of handling devices: ± 6 inches

(l) Slab Void position: ± 1/2 inch from end of void to center tie hole + 1 inch adjacent to end block

(m) Square ends (deviation from square): ± 1/2 inch

(n) Skew ends (deviation from designated skew): ± 1/2 inch

(o) Beam seat bearing area (variation from plane surface when tested with a straightedge through middle half of member):

± 1/8 inch

(p) Dowel tubes (spacing between the centers of tubes and from the centers of tubes to the ends and sides of members):

± 1/2 inch

(q) Tie rod tubes (spacing between the center of tubes and from the centers of tubes to the end of the member): ± 1/2 inch

(r) Tie rod tubes (spacing from centers of tubes to the bottom of the beams):
± 3/8 inch

(s) Total width of deck: Theoretical width ± 1/2 per joint

(t) Position of side inserts: ± 1/2 inch

(u) Position of weld plates: ± 1 inch

(4) Precast Minor Structures:

The maximum allowable tolerances or deviations from the dimensions shown on the drawings shall be as follows:

(a) Over-all dimensions of member: ± 1/4 inch per 10 feet; maximum of ± 3/4 inch

(b) Cross-sectional dimensions:

Sections six inches or less: ± 1/8 inch

Sections 18 inches or less and over 6 inches: ± 3/16 inch

Sections 36 inches or less and over 18 inches: ± 1/4 inch

Sections over 36 inches: ± 3/8 inch

(c) Deviations from straight line:

Not more than 1/4 inch per 10 feet

All exposed, sharp corners of the concrete shall be filleted 3/4 inch with a maximum allowable deviation of ± 1/8.

601-4.03 Compressive Strength and Acceptance:

Sampling and testing for compressive strength and acceptance for compressive strength will be in accordance with the requirements of Subsection 1006-7.

601-4.04 Opening to Traffic:

No vehicular traffic will be allowed on the structure until after the structure has been prestressed, tendons grouted, and all falsework removed from under the superstructure, for cast-in-place prestressed structures.

No vehicular traffic will be allowed on the structure until at least 10 days after the last concrete has been placed in each continuous portion of a structure and until the compressive strength of all placed concrete has reached the required 28-day compressive strength on structures in which cast-in-place concrete has been used.

601-5 Method of Measurement:

When concrete is to be paid for by the cubic yard, measurement will be made in accordance with the dimensions shown on the plans or such other dimensions as may be ordered in writing by the Engineer. No deduction will be made for the volume occupied by reinforcing steel, structural steel, prestressing materials, or pile ends embedded in the concrete.

The quantity of precast, prestressed structural members shall be measured to the nearest linear foot for each type and size of girder, box beam, or voided slab, as shown on the bidding schedule, installed in place, complete and accepted. Each member shall include the concrete, steel reinforcement and prestressing steel, enclosures for prestressing steel, anchorages, plates, nuts, elastomeric bearing pads, and such other materials contained within or attached to the unit.

Deck joint assemblies will be measured by the linear foot. Measurement will be made along the center line of the joint and at the surface of the roadway or sidewalk from face-of-curb or barrier to face-of-curb or barrier. Measurement will be to the nearest linear foot. No measurement will be made for that portion of the deck joint assembly required by plan details to extend through the face-of-curb or barrier, such being considered as incidental to the sealing of the joint.

Measurement for vertical restrainers will be made for each restrainer acceptably installed in place for each bridge.

Traffic and Pedestrian Rail will be measured by the linear foot, determined from the outside dimensions of the rail. Pedestrian Fence and Curb, Pedestrian Fence and Parapet, and Fence and Parapet will be measured to the nearest linear foot from end post to end post. Measurements will be to the nearest linear foot.

Bridge Concrete Barrier, Type A, B, or C, will be measured to the nearest linear foot. Bridge Concrete Barrier Transition will be measured as a unit for each constructed.

Reinforced Concrete Approach Slab will be measured to the nearest square foot.

Reinforced Concrete Anchor Slab will be measured to the nearest square foot. No measurement will be made for the reinforced concrete anchor lugs.

No measurement or direct payment will be made for grooving of the bridge deck, the cost being considered as included in contract items.

601-6 Basis of Payment:

Structural concrete in concrete structures, measured as provided above, will be paid for by the linear foot or by the cubic yard, complete in place, except that an adjustment, to the nearest cent, in the contract unit price will be made for the quantity of concrete represented by the results of a cylinder strength test that is less than the specified 28-day compressive strength, in accordance with the following table:

Adjustment in Contract Unit Price For Deficiency in Strength of Structural Concrete	
Percent of Specified 28-Day Compressive Strength Attained, to the Nearest One Percent	Percent of Contract Unit Price Allowed
100 or more	100
98 - 99	95
96 - 97	90
95	85
Less than 95 *	55
* If allowed to remain in place	

The contract price paid for structural concrete shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals and for doing all work involved in furnishing, placing, and curing concrete and transporting and erecting falsework, forms, precast concrete items, water stops, roadway drains, scuppers, metal hinges, and bearing pads to provide a concrete structure complete in place as shown on the project plans, as specified herein, and as directed by the Engineer.

The accepted quantities of deck joint assemblies, measured as provided above, will be paid for at the contract unit price per linear foot complete in place, including the seal, anchorage system, galvanizing, equipment and labor.

The accepted quantities of Vertical Restrainers, as measured above, will be paid for in accordance with the provisions of Subsection 109.10, Lump Sum Payment for Structures.

Payment for minor structures will be made under the various sections of the specifications covering that particular minor structure.

The accepted quantities of Traffic and Pedestrian Rail, Pedestrian Fence and Curb, Pedestrian Fence and Parapet, and Fence and Parapet, measured as provided above, will be paid at the contract unit price, complete in place, including all concrete, reinforcing steel, rail, other materials, and labor. Reinforcing steel embedded below the curb, parapet or barrier shall be included in the deck slab, wingwall, approach or anchor slab.

The accepted quantities of Bridge Concrete Barrier, Type A, B, or C, and Bridge Concrete Barrier Transition, measured as provided above, will be paid at the contract unit price, complete in place, including all concrete, reinforcing steel, rail, other materials, and labor. Reinforcing steel embedded below the barrier or transition shall be included in the superstructure, wingwall, approach or anchor slab as appropriate.

The accepted quantities of Reinforced Concrete Approach Slab, measured as provided above, will be paid for at the contract unit price, complete in place, including all concrete, reinforcing steel, labor, tools, equipment and incidentals.

The accepted quantities of Reinforced Concrete Anchor Slab, measured as provided above, will be paid for at the contract unit price, complete in place, including all concrete, reinforcing steel, labor, tools, equipment, and incidentals. No payment will be made for furnishing all materials and constructing reinforced concrete anchor lugs, the cost being considered as included in the contract bid item for the reinforced concrete anchor slab.

SECTION 602 PRESTRESSING CONCRETE:

602-1 Description:

The work under this section shall consist of prestressing precast and cast-in-place concrete by furnishing, placing and tensioning of prestressing steel in accordance with the details shown on the project plans, and the requirements of these specifications.

The work under this section shall also include the furnishing and installation of any appurtenant items necessary for the particular prestressing system to be used, including but not limited to ducts, anchorage assemblies and grout used for pressure grouting ducts for post-tensioning systems and strand deflection devices, such as hold-downs and hold-ups for pretensioning systems.

Prestressing for precast concrete members shall be performed by the pretensioning method. Prestressing for cast-in-place concrete structures shall be performed by the post-tensioning method.

602-2 Materials:

602-2.01 Reinforcing Steel and Prestressing Steel:

Materials furnished for reinforcing steel shall conform to the requirements of Section 1003.

Prestressing steel shall be high-tensile steel wire, high-tensile seven-wire strand or high-tensile alloy bars, as shown on the project plans.

High-tensile steel wire shall conform to the requirements of AASHTO M 204.

High-tensile seven-wire strand shall conform to the requirements of AASHTO M 203 for Grade 270. In addition to the 0.5-inch diameter prestressing steel shown on the project plans, 0.6-inch diameter seven-wire strand may be used for cast-in-place prestressed structures.
High-tensile alloy bars shall conform to the requirements of AASHTO M 275.

All prestressing steel shall be satisfactorily protected from damage by abrasion, moisture, rust, or corrosion and shall be free of dirt, rust, oil, grease, or other deleterious substances when installed and when tensioned.

602-2.02 Ducts:

Duct enclosures for post-tensioning steel shall be rigid galvanized ferrous metal.

602-2.03 Grout:

Cement grout for bonding post-tensioning tendons shall consist of not more than five gallons of water to one 94-pound bag of Portland cement and may contain an admixture if approved by the Engineer. The use of admixtures shall conform to the requirements of Subsection 1006-2.04(C). No admixtures containing chlorides or nitrates shall be used.

Portland cement shall be Type II conforming to the requirements of Subsection 1006-2.01.

Water shall conform to the requirements of Subsection 1006-2.02.

602-2.04 Structural Steel:

Material furnished for structural steel shall conform to the requirements of Section 1004.

602-2.05 Portland Cement Concrete:

Portland cement concrete shall conform to the requirements of Section 1006 for the class and strength of concrete shown on the project plans.

602-3 Construction Requirements:

602-3.01 Shop Drawings:

(A) General:

Shop drawings of the proposed prestressed concrete members shall be submitted in accordance with the requirements of Subsection 105.03.

The drawings shall show the method and procedure of jacking and the type, size, and properties of the strands and number of strands. The size, shapes, dimensions, and concrete cover shall be shown for the reinforcing steel, including any reinforcing steel to be relocated or added.

Calculations shall be submitted showing the elongation of the strands at the time of jacking, the initial forces in the strands, and the final working forces. These calculations may be submitted separately from the drawings, and should also include the latest calibration certifications for the jacking system. In addition, a graph shall be prepared showing the gauge pressure in pounds per square inch and force in thousands of pounds plotted through the whole range of the tensioning calibration. Not more than two years shall have elapsed between any jack calibration.

In addition to all required working drawings, the contractor shall prepare composite drawings in plan, elevation and section which show to scale the relative positions of all items that are to be embedded in the concrete and their embedment depth for the portions of the structure that are to be prestressed. Such embedded items include the prestressing ducts, vents, anchorage reinforcement and hardware, reinforcing steel, anchor bolts, earthquake restrainers, deck joint assemblies, drainage systems, utility conduits and other such items. Such drawings shall be adequate to ensure that there will be no conflict between the planned positions of any embedded items, and that concrete cover will be adequate. If during the preparation of such drawings conflicts are discovered, the contractor shall revise its working drawing for one or more of the embedded items, or propose changes in the dimensions of the work as necessary to eliminate the conflicts or provide proper cover. Any such revisions shall be approved by the Engineer before work on an effected item is started.

(B) Pretensioning Method:

The shop drawings shall show the strand locations and harping points of the strands.

The drawings shall identify the type of finish or surface condition on the top of the precast member.

(C) Post-Tensioning Method:

The drawings shall show the type, size, and properties of the strands or bars and the anchorage assemblies. The number of strands per tendon shall be shown. Details in addition to those shown on the contract plans shall be included for any additional reinforcing

steel required to resist the concrete bursting stresses in the vicinity of the anchorage assemblies. The force or stress diagram shall be shown on the drawings. The sizes, shapes, dimensions, and concrete cover shall be shown for the ducts. Lay-out dimensions for locating the ducts along the tendon path shall not exceed 15-foot intervals. Vent locations and details of the vents shall also be included on the drawings.

Calculations shall be submitted showing the stresses in the anchorages and distribution plates.

The drawings shall include complete details of the method, materials, and equipment proposed for use in the prestressing operations. Such details shall outline the method and sequence of jacking, complete details of the prestressing steel, anchoring devices, type of enclosures, block-outs, and all other data pertaining to the post-tensioning system or operations.

602-3.02 Approval of Prestressing Systems:

The contractor is responsible for furnishing either basic or special anchorage devices which satisfy the anchor efficiency requirements of AASHTO Division II, Article 10.3.2. The anchor efficiency test shall be conducted by an independent testing agency acceptable to the Engineer.

A basic anchorage device is an anchorage device meeting the restricted bearing compressive strength limits and the minimum plate stiffness requirements as specified in AASHTO Article 9.7.2 Division I - Design. If basic anchorage devices are used, the contractor is responsible for the design of the anchorage device and for determining the required concrete strength.

A special anchorage device is an anchorage device whose adequacy must be proven experimentally in the standardized acceptance test and met the acceptance criteria specified in AASHTO Article 10.3.3 Division II - Construction. If special anchorage devices are used, the contractor is responsible for furnishing anchorage devices that satisfy the acceptance test requirements of Division I, Article 9.21.7.3 and of Division II, Article 10.3.2.3. This acceptance test shall be conducted by an independent testing agency acceptable to the Engineer. The contractor shall provide records of the acceptance test in conformance with Division II, Article 10.3.2.3.12 to the Engineer and shall specify auxiliary and confining reinforcement, minimum edge distance, minimum anchor spacing, and minimum concrete strength at time of stressing required for proper performance of the local zone.

Post-tensioning systems which have been tested and approved by the California Department of Transportation (Caltrans) will be considered an acceptable alternate to the AASHTO testing criteria. A copy of the approval letter from the Caltrans “Division of New Technology and Research,” including any details associated with the approval, shall be submitted with the shop drawings by the post-tensioning company.

The contractor shall provide a calibration of the post-tensioning jacking system and shall provide the appropriate control settings for the Department's transducer, electro-hydraulic

load cell system by testing the jacking system in a manner that has been pre-approved by the Engineer.

Any deviation from the approved materials and details will not be permitted unless new details are submitted by the contractor and approved in advance of use.

The approval of any proposed method, material or equipment shall not operate to relieve the contractor in any respect of full responsibility for successfully completing the prestressing in accordance with details shown on the project plans and the requirements of these specifications.

602-3.03 Sampling and Testing:

Sampling and testing shall conform to the requirements of AASHTO M 203, AASHTO M 204 and as specified herein.

Samples from each size and each heat of prestressing bars, from each manufactured reel of prestressing steel strand, from each coil of prestressing wire, and from each lot of bar couplers to be used shall be furnished for testing. With each sample of prestressing steel wires, bars or strands furnished for testing, there shall be submitted a Certificate of Compliance, conforming to the requirements of Subsection 106.05, stating the manufacturer's minimum guaranteed ultimate tensile strength of the sample furnished.

All materials for testing shall be furnished by the contractor at no additional cost to the Department. The contractor shall have no claim for additional compensation in the event its work is delayed awaiting approval of the materials furnished for testing.

All bars of each size from each mill heat, all wire from each coil, and all strand from each manufactured reel to be shipped to the job site shall be assigned an individual lot number and shall be tagged in such a manner that each lot can be accurately identified at the job site. Each lot of anchorage assemblies and bar couplers to be installed at the job site shall be likewise identified. All unidentified prestressing steel, anchorage assemblies or bar couplers recovered at the job site will be rejected.

602-3.04 Anchorage and Distribution for Post-Tensioned Structures:

All post-tensioned prestressing steel shall be secured at the ends by means of approved permanent type anchoring devices.

The load from the anchoring device shall be distributed to the concrete by means of approved devices that will effectively distribute the load to the concrete by meeting the requirements of a basic anchorage device or a special anchorage device.

Both basic and special anchorage devices must also meet the following anchor efficiency test criteria: the anchorage device shall hold the prestressing steel without exceeding anticipated set at a load producing a stress of not less than 95 percent of the guaranteed minimum tensile strength of the prestressing steel.

602-3.05 Duct Installation for Post-Tensioned Structures:

Duct enclosures for prestressing steel shall be mortar-tight and accurately placed at the locations shown on the project plans or approved by the Engineer.

Ducts shall be fabricated with either welded or interlocked seams. Galvanizing of the welded seam will not be required. Ducts shall have sufficient strength to maintain their correct alignment during placing of concrete. Joints between sections of duct shall be positive metallic connections which do not result in angle changes at the joints. Waterproof tape shall be used at all connections. Transition couplings connecting ducts to anchoring devices need not be galvanized.

All ducts or anchorage assemblies shall be provided with pipes or other suitable connections for the injection of grout after prestressing.

Ducts for prestressing steel shall be securely fastened in place to prevent movement and displacement during concreting. Ducts shall be placed within ± 1/4 inch of the dimensions shown on the approved shop drawings.

After installation in the forms, the ends of ducts shall at all times be covered as necessary to prevent the entry of water or debris. If prestressing steel is to be installed after the concrete has been placed, the contractor shall demonstrate to the satisfaction of the Engineer that the ducts are free of water and debris immediately prior to installation of the steel.

Prior to placing forms for closing slabs of box girder cells, the contractor shall demonstrate to the satisfaction of the Engineer that all ducts are unobstructed and if the prestressing reinforcement has been placed, that the steel is free and unbonded in the duct.

Prior to placing the forms for closing slabs of box girder cells, the contractor shall demonstrate to the Engineer, by aerostatic or hydrostatic tests, that the duct system will not permit leakage of grout into the box girder cells. For ducts completely encased in concrete, such tests shall be performed with a charging pressure of 40 pounds per square inch. Once the charging pressure is attained, the mechanical shut-off valve shall be closed for a period of not less than five minutes. A retained pressure of 20 pounds per square inch, or greater, after five minutes, will be considered an indication of acceptable performance.

Ducts not completely encased in concrete shall have the exposed areas sealed with an epoxy compound and then pressure tested to 20 pounds per square inch for five minutes. A retained pressure of 10 pounds per square inch or greater, after five minutes, will be considered an indication of acceptable performance.

All leaks shall be repaired and the ducts retested prior to placing the forms. If, after two attempts to repair leaks, the ducts still do not comply with the above performance requirements, the Engineer may accept the ducts if the Engineer is satisfied that no significant leakage of grout will occur. After completing each aerostatic or hydrostatic test, the ducts shall be blown dry with oil-free compressed air.

602-3.06 Prestressing:

(A) General:

Unless otherwise shown on the project plans, the stresses in the prestressing steel shall not exceed those specified in the current edition of the AASHTO Standard Specifications for Highway Bridges. However, when low relaxation strands are used in post-tensioning cast-in-place concrete, the jacking force shall not exceed 78 percent of the minimum ultimate tensile strength of the prestressing steel.

Working force will be considered as the force remaining in the prestressing steel after all losses, including creep and shrinkage of concrete, elastic compression of concrete, losses in prestressing steel due to sequence of stressing, friction, and all other losses peculiar to the method or system of prestressing have taken place or have been provided for.

All prestressing steel shall be tensioned with hydraulic jacks so that the force in the prestressing steel shall not be less than the value shown on the project plans. Each jack used shall be equipped with either a pressure gauge or a load cell to determine the jacking force. All jacks and gauges shall be calibrated as a unit and shall be accompanied by a certified calibration chart.

All gauges shall be either a reading dial at least six inches in diameter or a digital display indicator. The increments shown on the reading dial gauge shall not exceed two percent of the jacking force. The digital display indicator shall be readable by normal vision at a distance greater than 10 feet. All gauges shall show a load accuracy of one percent of the load, from one percent to one hundred percent of the capacity of the gauge.

The certified calibration charts for the hydraulic jacks and pressure gauges may be checked before and during jacking operations with Department-furnished load cells. If the certified calibration is found to be in error, the operation shall be immediately discontinued until a new certified calibration is performed by the contractor.

Welding or a welding ground shall not be done near prestressing steel and ducts. Welding near prestressed work shall be done only if specified on the project plans or directed by the Engineer.

The tensioning process shall be so conducted that the force being applied and the elongation of the prestressing steel may be measured at all times. The actual elongation obtained from the calibrated force value shall be compared with the theoretical calculated elongation. If the actual measured elongation differs by more than five percent of the theoretical calculated elongation, the entire operation shall be carefully checked and the source of the error determined and corrected before proceeding with the tensioning. A record of the prestressing force and elongations shall be kept at all times and submitted to the Engineer for approval.

(B) Pretensioning Precast Concrete:

The tensioning force in pretensioned strands shall not be transferred to the member until tests on cylinder specimens made and cured under the same conditions as the member

indicates the required compressive release strength has been attained. This shall constitute the end of the curing period.

Detensioning shall be performed immediately following the curing period if the concrete has been heat-cured. The release of the strands shall be from one or both ends of the casting bed depending upon which method will produce the least movement of members in the casting bed and the least horizontal eccentricity of the initial prestressing force in the member.

All pretensioned members shall be tensioned either by single strand or multiple strand jacks.

Jacking the prestressing steel shall be performed in two increments. An initial tension shall be applied to the strands to straighten them, to eliminate slack and provide a starting or reference point for measuring elongation. The final tension shall then be applied and elongation of strands measured.

Anchoring devices shall be capable of holding strands with a minimum of differential slippage. Stringing of following lengths of strand incorporating points previously gripped within lengths to be stressed will not be permitted. Any rotation of the strand shall be limited to not more than one revolution per 100 feet of exposed strand.

Splicing of strands will be permitted but only one splice per strand will be allowed. Strands to be spliced shall have the same lay or direction of twist. Splicing will not be permitted within the member.

When ordered by the Engineer, prestressing strands in precast members, if tensioned individually, shall be checked by the contractor for loss of force not more than three hours prior to placing concrete for the members. The method and equipment for checking the loss of force shall be subject to approval by the Engineer. All strands which show a loss of prestress in excess of three percent shall be retensioned to the original jacking force.

When concrete has not been placed within seventy-two hours of the tensioning of the prestressing strands, retensioning of all strands will be required prior to placing of the concrete.

(C) Post-Tensioning Cast-in-Place Concrete:

Prestressing steel for post-tensioning, which is installed in structures prior to placing and curing of the concrete, shall be continuously protected against rust or other corrosion until grouted by means of an approved corrosion inhibitor placed in the ducts or applied to the steel in the duct. If the strands are in the duct at the time concrete is placed, no tensioning will be allowed until it is demonstrated to the satisfaction of the Engineer that the prestressing strands are free and unbonded in the duct.

When prestressing steel for post-tensioning is installed in the ducts after completion of concrete curing, and if stressing and grouting are completed within 10 calendar days after the installation of the prestressing steel, rust which may form during the 10 days will not be cause for rejection of the steel.

Except as herein provided, cast-in-place concrete shall not be prestressed until at least seven days after the last concrete has been placed in the structure to be prestressed and until the compressive strength of all placed concrete, has reached the required strength for jacking.

Prestressing steel shall be tensioned by jacking from each end of the tendon for continuous structures unless otherwise noted on the project plans. Such jacking of both ends need not be done simultaneously, unless specifically indicated on the plans or in the Special Provisions.

Prestressing steel may be tensioned by jacking from one end only for simple span structures.

Should the contractor elect to furnish an anchoring device of a type which is sufficiently large and which is used in conjunction with a steel grillage embedded in the concrete that effectively distributes the compressive stresses to the concrete, the steel distribution plates or assemblies may be omitted.

Where the end of a post-tensioned assembly will not be covered by concrete, the anchoring devices shall be recessed so that the ends of the prestressing steel and all parts of the anchoring devices will be at least two inches inside of the end surface of the members, unless a greater embedment is shown on the project plans. Following post-tensioning, the recesses shall be filled with concrete for the structure and finished flush.

At no time will a cutting torch be allowed for cutting prestressing steel for cast-in-place prestressed structures.

602-3.07 Grouting of Post-Tensioned Members:

Post-tensioned prestressing steel shall be bonded to the concrete by completely filling the entire void space between the duct and the tendon with grout.

All of the tendons in a cast-in-place concrete structure shall have been fully tensioned and anchored prior to any grouting operation.

The grout shall be mixed in mechanical mixing equipment of a type that will produce uniform and thoroughly mixed grout. Water shall be first added to the mixer followed by cement. Retempering of grout will not be permitted. All grout shall pass through a screen with 1/8-inch maximum clear openings prior to being placed in the grouting equipment and shall be continuously agitated until it is pumped.

The quality of the grout shall be determined by the Engineer in accordance with the requirements of Arizona Test Method 311. The efflux time of a grout sample immediately after mixing shall be not less than 11 seconds.

The maximum temperature of the grout shall be 90 degrees F and the minimum 50 degrees F.

Grouting equipment shall be capable of grouting at a pressure of at least 150 pounds per square inch and shall be furnished with a pressure gauge having a full scale reading of not more than 300 pounds per square inch. Maximum grouting pressure shall not exceed 250 pounds per square inch.

Standby flushing equipment capable of developing a pumping pressure of 250 pounds per square inch and of sufficient capacity to flush out any partially grouted ducts shall be provided and available at the job site. Equipment capable of providing dry, oil free compressed air for removing water from the ducts shall be available at the site.

All ducts shall be clean and free of deleterious materials that would impair bonding of the grout or interfere with grouting procedures. Compressed air used to blow out the ducts shall be oil free.

Grout injection pipes shall be fitted with positive mechanical shutoff valves. Ejection pipes shall be fitted with valves capable of withstanding the pumping pressures. Valves shall not be removed or opened until the day following the grouting operation, unless otherwise approved by the Engineer. Draped tendons exceeding 400 feet shall be vented at all high points. Grout vents shall be made of rigid tubing or pipe with threaded fittings and shutoff valves.

Grout shall be injected at the low end of the duct and continuously wasted at the outlet until no visible slugs of water or air are ejected. The outlet pipe shall then be closed and the duct shall then be pressurized. The pressurized duct shall maintain a minimum pressure of 75 pounds per square inch for a minimum time of one minute. The valve at the inlet shall then be closed while maintaining this minimum pressure.

When hot weather conditions would contribute to quick stiffening of the grout, the grout shall be cooled by approved methods as necessary to prevent blockages during pumping operations. The use of an approved chemical admixture should also be considered for increasing the pumping efficiency and/or time of set.

When freezing weather conditions will prevail during and following the placement of grout, the contractor shall provide adequate means to protect the grout in the ducts from damage by freezing.

The surfaces of concrete against which concrete encasement over anchorage assemblies is to be placed shall be abrasive blast cleaned and aggregate exposed after grouting of the ducts has been completed.

602-3.08 Finishing Precast Concrete:

The finishing of precast concrete bridge members shall comply with the requirements of Subsection 601-3.05. In addition, those exterior surfaces of exterior bridge members normally in the view of vehicular or pedestrian traffic shall be finished in accordance with the requirements for a Class II Finish.

Unless otherwise specified on the plans, the top surface of I-beams, box beams, and flat slabs shall be roughened with a hand tine rake while the concrete is still plastic.

All projecting strands that are not scheduled to remain for future embedment shall be cut off at the surface of the concrete. Strands that are to remain shall be cut and bent to the dimensions shown on the plans. If the end of the precast bridge member will not be embedded in cast-in-place concrete, then all the strands shall be cut or ground flush with the surface of the concrete and thoroughly coated with a bitumastic type sealant.

Exposed uncoated reinforcing bars and strand shall be cleaned of concrete laitance and other foreign materials. If concrete laitance are allowed to harden and other foreign materials to remain on the bars, then abrasive blast methods will be conducted for cleaning. The cleaning of exposed epoxy-coated reinforcing steel shall be limited to methods not damaging to the coating, the actual cleaning to be completed while the concrete laitance are still plastic. Any damage done to the epoxy coating shall be repaired in accordance with Subsection 605-3.03(B).

The work described in this subsection shall be accomplished in the production yard of the precast manufacturer. When the fabrication of any precast bridge member has been successfully completed, as determined by inspection, the unit will then be approved for transportation.

602-4 Method of Measurement:

No measurement or direct payment will be made for prestressing precast concrete, the cost being considered as included in the cost of the precast concrete item.

Prestressing concrete in cast-in-place structures will be measured by the approximate station for which a lump sum item is listed in the bidding schedule for such work.

602-5 Basis of Payment:

Prestressing cast-in-place concrete will be paid at the contract lump sum price, complete in place.

Furnishing and placing reinforcement not shown on the project plans and required only for anchorage zone recesses, blocks, duct ties and grillage assemblies, as recommended by the post-tensioning system used, shall be considered as included in the lump sum price paid for prestressing cast-in-place concrete.

Furnishing and placing concrete used in girder web flares and for concrete used in external anchorage blocks, including cover of distribution plates, shall be considered as included in the contract lump sum price paid for prestressing cast-in-place concrete.

Partial payments may be made in accordance with the provisions of Subsection 109.07.

Payments will be made on the basis of the following:

(1) Installation of Ducts: 25 Percent of Contract Lump Sum

(2) Installation of Tendons: 50 Percent of Contract Lump Sum

(3) Completion of Tensioning: 15 Percent of Contract Lump Sum

(4) Completion of Grouting: 10 Percent of Contract Lump Sum

SECTION 603 PILING:

603-1 Description:

The work under this section shall consist of the furnishing and driving piles at the locations and in accordance with the details shown on the plans and in accordance with the requirements of these specifications.

Piling shall consist of steel piles, cast-in-place concrete piles, precast concrete piles and timber piles and shall be of the kinds, sizes and lengths shown on the project plans.

When load test piles are shown on the project plans, pile loading tests shall be performed on said test piles in accordance with the requirements of the Special Provisions and as directed by the Engineer.

603-2 Materials:

603-2.01 Steel Piles:

Steel piles shall be of the section shown on the project plans and shall be structural steel conforming to the requirements of AASHTO M 183.

Pile points, when specified on the project plans or ordered by the Engineer, shall be cast steel and be specially manufactured for hard pile driving.

603-2.02 Cast-in-Place Concrete Piles:

Cast-in-place concrete piles shall consist of steel shells driven permanently to the required bearing value and penetration and filled with concrete.

Concrete for filling cast-in-place concrete piles shall be Class S Portland cement concrete of the compressive strength shown on the plans and shall conform to the requirements of Section 1006.

Steel shells shall be of the diameter, thickness, length and design shown on the project plans. The shells shall be of sufficient strength and rigidity to permit driving and to prevent distortion caused by soil pressures or the driving of adjacent piles. The shells shall also be sufficiently watertight to exclude water during the placing of the concrete.

Unless otherwise shown on the plans or ordered by the Engineer, steel shells shall be equipped with closed driving tips. Driving tips shall be not more than 1/2 inch greater in diameter than the diameter of the shell at the tip. Closed driving tips may consist of flat steel plates of sufficient strength to suit pile driving conditions or may be cast steel points suitable for driving conditions. The use of wedge tips constructed of flat steel plates will not be permitted.

Reinforcing steel shall be as shown on the project plans and shall conform to the provisions of Section 1003.

603-2.03 Precast Concrete Piles:

Precast concrete piles shall be either conventionally reinforced concrete piles or precast prestressed piles with prestressed steel strands.

Concrete shall be Class S concrete of the compressive strength shown on the plans and shall conform to the requirements of Section 1006.

Precast concrete piles shall be constructed in accordance with the details shown on the plans and in accordance with the requirements of Section 601. Prestressing shall be in accordance with the requirements of Section 602 using the pretensioning method.

Steel reinforcement shall conform to the requirements of Section 1003.

Precast concrete piles shall be fabricated on casting beds founded on permanent concrete foundations using steel forms, unless otherwise approved by the Engineer. Outer forms shall enclose all except the top horizontal surface of the pile. The side forms may have a maximum draft on each side not exceeding 1/4 inch per foot. All corners shall be chamfered two inches or rounded to a two-inch radius.

Forms for piles shall be such as to avoid the formation of fins at the intersection of the surfaces. The top of the concrete casting shall be given a uniformly smooth finish to match the finish surface at the formed sides.

Pile ends shall have plane surfaces and be perpendicular to the longitudinal axis of the pile. The maximum sweep (deviation from straightness measured along two perpendicular faces of the pile while not subject to bending forces) shall not exceed 1/8 inch in any 10 feet of its length, 3/8 inch in any 40 feet, or 3/16 inch times total length in feet divided by 20 feet.

Pick-up points for piles shall be plainly marked on all piles after removal of the forms, unless special lifting devices are attached for pick-up and all lifting shall be done at these points.

The use of special embedded or attached lifting devices, the employment of other pick-up points or any other method of pick-up shall be subject to written approval by the Engineer.

603-2.04 Timber Piles:

All timber piles shall conform to the requirements of ASTM D 25. Treated timber piles shall be either Southern yellow pine, Ponderosa pine, Douglas fir or Larch. All piles for permanent structures shall be cleaned.

Timber piles requiring treatment shall be pressure treated in accordance with the requirements of AASHTO M 133.

Treated piles will be inspected for grade and quality before treatment and each piece accepted for treatment will be hammer-marked on the butt end with the registered brand of the inspector.

603-2.05 Paint:

Paint for steel piles or metal shells shall be of the type shown on the project plans and shall conform to the requirements of Section 1002.

603-2.06 Certificates:

Certificates of Analysis conforming to the requirements of Subsection 106.05 shall be furnished for all steel piling and steel shells used.

603-3 Construction Requirements:

603-3.01 General:

When the project plans or specifications permit the use of more than one type of pile, the same type of pile shall be used for all piles within each individual footing, unless otherwise permitted by the Engineer. The contractor shall be responsible for furnishing piling of sufficient length to obtain the penetration and bearing value required.

603-3.02 Predrilled Holes:

Piles to be driven through embankment constructed by the contractor shall be driven in holes drilled or spudded through the embankment when shown on the project plans or ordered by the Engineer. The hole shall have a diameter of not less than the greatest dimension of the pile cross section plus six inches. After driving the pile the space around the pile shall be filled to ground surface with dry sand or pea gravel, or as specified on the plans.

603-3.03 Equipment:

(A) General:

Steam or air hammers shall be furnished with boiler or air capacity at least equal to that specified by the manufacturer of the hammers to be used. The boiler or compressor shall be equipped with an accurate pressure gauge at all times. The valve mechanism and other parts of steam, air, or diesel hammers shall be maintained in first class condition so that the length of stroke and number of blows per minute for which the hammer is designed will be obtained. Inefficient steam, air, or diesel hammers shall not be used.

(B) Hammers for Steel Piles:

Steel piles shall be driven with a steam or air or diesel hammer which shall develop an energy per blow of not less than 15,000 foot-pounds unless otherwise specified on the project plans.

(C) Hammers for Metal Shells:

Metal shells for cast-in-place concrete piles shall be driven with a steam or air or diesel hammer. For shells driven with the aid of a mandrel, the combined weight of the shell and the mandrel shall be considered as the weight of the pile. The hammer shall develop an energy per blow of not less than one foot-pound for each pound of weight driven. In no case shall the total energy developed by the hammer be less than 10,000 foot-pounds per blow for driving shells with a mandrel. Hammers used to drive metal shells without a mandrel shall develop an energy per blow of not less than 15,000 foot-pounds.

(D) Hammers for Timber Piles:

Drop hammers may be used for timber piles and shall weigh not less than 3,000 pounds and shall be equipped with efficient leads and hoisting equipment. The fall of the hammer shall not exceed 12 feet.

(E) Leads:

Pile driver leads shall be constructed in such a manner as to afford freedom of movement to the hammer and they shall be blocked or braced so that the initial driving of the pile can be done without rotation or shifting of the pile and to assure concentric hits on the piles.

(F) Followers:

Driving of piles with followers will not be permitted.

603-3.04 Driving Piles:

(A) General:

All piles shall be driven to a minimum bearing value or to a required tip elevation or a combination of both, as follows:

Where a minimum bearing value is specified, all piles shall be driven to a bearing value not less than that specified, regardless of tip elevation. Where a required tip elevation is specified and no bearing value is specified, all piles shall be driven to at least the required tip elevation using a hammer that is capable of overcoming the soil resistance to reach that elevation without causing damage to the pile. Where a minimum bearing value and a required tip elevation are both specified, the piles shall be driven to a bearing value not less than that specified and, in addition, if the required tip elevation has not been attained, shall be driven further to the required tip elevation. The required tip elevation shall be the

estimated tip elevation shown on the project plans or the adjusted elevation when allowed by the project plans for increased bearing value.

Piles shall not be driven until after the excavation or embankment in the area of the piling is complete. Any material forced up between the piles shall be removed to correct elevation without cost to the Department before concrete for the foundation is placed.

Piles shall be accurately spaced and shall be driven either vertically or to the batter shown on the project plans. For trestle work and for piles which extend above ground in the completed structure, care shall be exercised to obtain proper alignment. Piles materially out of line shall be pulled and redriven or additional piles shall be driven as directed. Piles which are to be capped shall be accurately cut off so that true bearing is obtained on all piles without the use of shims. Piles cut off otherwise shall be replaced.

Insofar as practicable, the driving of individual piles shall be a continuous operation.

(B) Driving Steel Piles:

The heads of steel piles shall be cut squarely and a cast or structural steel driving head or cap shall be used to hold the axis of the pile in line with the axis of the hammer and to prevent excessive upsetting of the pile head under extremely hard driving conditions.

(C) Driving Metal Shells:

An approved driving head, as furnished by the manufacturer or equal, which shall be of proper size and design for the particular size and type of hammer to be used, shall be provided to distribute properly the hammer blows and to prevent damage to the shell while driving.

The contractor shall have available at all times a suitable light, of an approved type, for thoroughly illuminating the interior of the pile shells for their entire length after being driven. Any shell that shows bends, kinks or other deformations incurred during the process of driving that would impair the strength or efficiency of the completed pile shall be replaced as directed by the Engineer and at the expense of the contractor. After all the shells have been driven to proper alignment, spacing and elevation and cut off at the required elevation, they shall be given a final inspection before they are filled with concrete. Any water or other foreign substance found in them shall be removed. Any required reinforcing steel shall be placed into the shell and supported and blocked to hold it in position during the concreting operation.

Upon approval, the shells shall be filled with concrete in the presence of the Engineer. The concrete shall be placed in layers and vibrated in accordance with the requirements of Subsection 601-3.03.

(D) Driving Timber Piles:

Long piles shall be adequately supported against lateral buckling during the driving process.

All timber piles shall have square recut heads and tips and when necessary, the heads shall be accurately shaped or chamfered to take rings or head blocks.

Collars, bands or other devices shall be provided where necessary to prevent splitting or brooming of the timber piles. Tips shall be properly formed to take shoes if, in the judgment of the Engineer, shoes are found necessary. They shall be furnished and attached to the piles by the contractor as directed. The contractor shall do all work necessary or incidental to the furnishing and proper fitting and fastening of said shoes to the piles and any other work necessary in driving the piles.

Treated timber piles shall be carefully handled so that the outer fibers are not broken or unduly injured. Treated piles which have been roughly handled in shipment or driving will be rejected. All treated piles shall be handled by fiber rope slings or other means which will not break the outer fibers. The use of peavies, cant hooks or other sharp tools will not be allowed.

The heads or butts of all treated timber piles, except those to be encased in concrete, shall be treated. After the piles have been driven and cut off to the proper elevation for the cross cap, the sawed surface shall be either covered with three applications of a mixture of 60 percent creosote oil and 40 percent roofing pitch or the surface shall be thoroughly brush coated with three applications of hot creosote oil and covered with hot roofing pitch. A covering of No. 24 gauge galvanized steel six inches in diameter larger than the diameter of the pile shall then be placed on the pile head and bent down over the sides of the pile to shed water.

(E) Driving Precast Concrete Piles:

The heads of concrete piles shall be protected from direct impact of the hammer by a cushion driving block. The cushion shall be maintained in good condition during the entire driving operation.

(F) Defective Piles:

The methods used in driving piles shall not subject them to excessive and undue abuse producing crushing and spalling of concrete, injurious splitting, splintering and brooming of the wood, or deformation of the steel. Manipulation of piles to force them into proper position, if considered by the Engineer to be excessive, will not be permitted.

A concrete pile will be considered defective if it has a visible crack, or cracks, extending around the entire periphery of the pile, or any defect which, as determined by the Engineer, affects the strength or life of the pile.

Defective or damaged piles, piles which are driven materially out of position, or timber piles which have been cut too short will be rejected. Rejected piles and any falsework piles shall be removed or cut at least two feet below the final ground surface, except that rejected piles which will interfere with the work shall be removed. Rejected shell piles which are left in place shall be filled with utility concrete conforming to the requirements of Section 922.

All piles pushed up by the driving of adjacent piles or by any other cause shall be driven down again.

603-3.05 Pile Splices:

Timber piles shall not be spliced, except upon written permission of the Engineer, in which case the method of splicing shall be in accordance with a working drawing submitted by the contractor to the Engineer for approval.

Metal shells and steel piles shall be spliced in accordance with the details shown on the plans. The indiscriminate splicing of steel piles will not be allowed.

Splicing of metal shells and steel piles shall be accomplished only by welders who have been prequalified and certified for the type of weld required.

Precast concrete piles shall not be spliced but instead shall be extended by casting a further length on top of the pile in accordance with the details shown on the project plans. Precast piles shall not be extended unless specified on the project plans or authorized in writing by the Engineer. If further driving is required, it shall not be done until the concrete has reached its 28-day strength.

In any case where the project plans do not show details of a splicing method, splices shall not be made until the Engineer has approved the method proposed by the contractor.

603-3.06 Pile Cutoff:

After driving has been completed, all piles shall be cut at the elevation determined by the Engineer. Cut-off material determined to be worth salvaging shall be stockpiled at an accessible and approved location on the site for removal by Department forces. Material determined to be unsatisfactory for salvaging shall be removed from the site and disposed of by the contractor. Steel piles and steel shells which are less than five feet in length will be considered unsatisfactory for salvage and shall become the property of the contractor.

Each pile shall be cut on a plane normal to its axis. Embedment and anchorage into concrete caps or footings shall be provided as shown on the project plans.

Unless otherwise shown on the project plans, precast concrete piles shall be trimmed off to three inches above the bottom of the cap or footing and the edges beveled. Vertical reinforcement shall be cut off to provide 18 inches of embedment, and prestressing strands shall be cut off to provide 24 inches of embedment into the cap or footing. Any concrete damaged below cut-off elevation in the driving or cutting shall be removed to solid material and the pile built back up to elevation as specified under Subsection 603-3.04.

603-3.07 Painting Metal Piles:

When steel piles or metal shells for cast-in-place concrete piles are driven and portions of these piles either extend above the ground or above the water surface, all surface thereof that will be exposed in the completed work shall be protected by three coats of paint. The

protection shall extend from an elevation two feet below the ground surface or two feet below low water level when the piles are in water, to the top of the exposed portion of the pile.

Painting of piles shall be in accordance with the requirements of Section 610.

603-3.08 Determination of Bearing Values:

The bearing value of each pile that is driven by a hammer shall be measured by the driving formula as specified herein. The contractor shall provide facilities and cooperation to the Engineer as needed to obtain the data required for this purpose.

TABLE 603-1

Type of Pile	Type of Hammer	Formula
Timber and Steel	Drop	$P = \frac{2\ F\ H}{S + 1.0}$
Metal Shells for Cast-In-Place Concrete, Timber, and Steel	Single-Acting Power	$P = \frac{2\ F\ H}{S + 0.1}$
	Double-Acting Power (Use either formula)	$P = \frac{2\ H\ (F + Ap)}{S + 0.1}$ $P = \frac{2\ E}{S + 0.1}$

P = safe allowable bearing value of piles, in pounds.
F = force of striking parts of the hammer, in pounds.
H = fall of hammer, in feet.
S = average penetration, in inches per blow, for the last five to 10 blows for drop hammers, and the last 10 to 20 blows for steam or air and diesel hammers.
A = effective area of piston, in square inches.
p = mean effective steam or air pressure, in pounds per square inch.
E = manufacturer's rating of energy developed by the hammer, in foot-pounds per blow.

The formulas in Table 603-1 are applicable only when:

The hammer has a free fall, except for double-acting hammers.

The head of the pile is not broomed or crushed.

The penetration is reasonably uniform.

There is no appreciable bounce after the blow. If there is an observable bounce, the value of H shall be reduced by twice the bounce height.

603-4 Method of Measurement:

603-4.01 Furnishing Piles:

Furnishing piles will be measured to the nearest linear foot of piles furnished in accordance with the lengths specified on the project plans or ordered by the Engineer, except that no measurement for payment will be made for furnishing piles which are subsequently damaged in handling or driving to the extent that they are unusable.

603-4.02 Driving Piles:

Driving piles will be measured to the nearest linear foot from the tip to the required cut-off point of all piles satisfactorily driven.

603-4.03 Splicing Piles:

Splicing piles will be measured as a unit for each splice made, when splicing is required because of pile lengths driven in excess of those specified on the project plans or ordered by the Engineer.

No measurement for payment will be made of splices made to obtain pile lengths in accordance with the details shown on the project plans or ordered by the Engineer.

603-5 Basis of Payment:

603-5.01 General:

The accepted quantities of each of the items of work listed on the bidding schedule, measured as provided above, will be paid for at the contract unit price, as follows: When more than one type of piling is shown, each type will be listed on the bidding schedule and paid for separately.

603-5.02 Furnishing Piles:

The contract price for furnishing piles shall include full compensation for furnishing precast concrete piles, steel piles, pile points or shoes, metal shells or pipe casings (for cast-in-place concrete piles) or timber piles delivered to the site of the work, in the quantities, types and sizes specified and lengths specified or ordered, in a condition ready to be driven.

Furnishing, fitting and fastening metal shoes for timber piles will be paid for in accordance with the requirements of Subsection 104.02.

603-5.03 Driving Piles:

The contract price for driving piles shall include full compensation for placing piles and metal shells or pipe casings and driving them at the locations specified and to the required bearing value and tip elevation; furnishing and placing Portland cement concrete and reinforcing steel in metal shells for cast-in-place concrete piles; for cutting piles off and furnishing and installing anchoring devices; and for painting piling as required.

The contract price for driving piles shall also include full compensation for jetting, drilling, blasting or other similar work as necessary to obtain the required tip elevation and furnishing

and attaching brackets, lugs, core stoppers or other similar devices to increase the bearing value of the piles, when such work or materials is specified on the project plans or in the Special Provisions.

When the work and materials described in the preceding paragraph are not specified on the project plans, but the Engineer determines, or it has been demonstrated to the Engineer's satisfaction, that the required tip elevation cannot be reached without jetting, drilling, blasting or other similar work, or that the required bearing value cannot be obtained without the use of brackets, lugs, core stoppers or other similar devices, the Engineer will order such work to be performed and such materials to be furnished as the Engineer considers necessary under the conditions encountered in order that the required tip elevation or bearing value may be obtained. Materials and labor necessary to accomplish the requirements will be paid for in accordance with the provisions of Subsection 104.02.

603-5.04 Splicing Piles:

The contract price for splicing piles shall include full compensation for furnishing all materials and labor and splicing piles in accordance with the specifications and the details shown on the project plans.

Payment for splicing piles will be made at the contract unit price per splice determined by multiplying the contract unit price per linear foot for furnishing the pile by a factor of five.

The total quantity of splicing piles necessary to complete the work may vary considerably from the quantity shown in the bidding schedule; however, no adjustment in the contract unit price due to an increase or decrease in quantity, as provided for in Subsection 104.02, will be made for this item.

SECTION 604 STEEL STRUCTURES:

604-1 Description:

The work under this section shall consist of constructing steel structures in accordance with the details shown on the plans and the requirements of these specifications. The work shall include furnishing, fabricating, erecting and painting the structural steel and other metals and performing all work required to complete the bridge structures and other structures.

604-2 Materials:

604-2.01 Structural Steel:

Structural steel shall conform to the requirements of ASTM A 36, unless otherwise specified or shown on the plans.

All rolled section girders or structural steel plate used for the fabrication of tension flanges, web plates, eyebars and hanger plates and for splice plates of tension flanges and eyebars shall meet the longitudinal Charpy V-notch impact value requirements specified herein. Sampling procedures shall conform to the provisions in ASTM A 673. The H (Heat)

frequency of testing shall be used for structural steels conforming to ASTM A 36, A 572 and A 588. The P (Piece) frequency of testing shall be used for structural steel conforming to ASTM A 514. Charpy V-notch impact values shall be determined in accordance with ASTM E 23.

Charpy V-notch (CVN) impact values shall conform to the following minimum values:

Material		Impact Value: (foot-pounds at Temp. ^{o}F)
ASTM A 36		15 at 40 ^{o}F
ASTM A 572*		15 at 40 ^{o}F
ASTM A 588*	2 inches and under	15 at 40 ^{o}F
ASTM A 588*	Over 2 to 4 inches	20 at 40 ^{o}F
ASTM A 514	2-1/2 inches and under	25 at 0 ^{o}F
ASTM A 514	Over 2-1/2 to 4 inches	35 at 0 ^{o}F
* If yield point of material exceeds 65,000 psi, the temperature for CVN impact value for acceptability shall be reduced 15 ^{o}F for each increment of 10,000 psi above 65,000 psi.		

604-2.02 Steel Structural Rivets:

Steel structural rivets shall conform to the requirements of ASTM A 502.

604-2.03 High-Strength Bolts, Nuts and Washers:

High Strength Bolts shall conform to ASTM A 325 except as may be modified herein.

The maximum hardness for ASTM A 325 bolts shall be 34 R_C.

Nuts and washers, appropriate to the type of high strength bolt to be used, shall conform to ASTM A 563 or A 194, for nuts, and F 436, for washers, respectively.

Nuts shall be Grade 2H or DH for black or galvanized bolts. For galvanized bolts the nuts shall be overtapped to the minimum amount required for the bolt assembly.

All nuts, bolts and washers shall have the manufacturers' markings on them.

(A) Certificate Of Analysis:

Each lot of bolts, nuts or washers shall be accompanied by a Certificate of Analysis.

The Certificate Of Analysis shall provide a lot number corresponding to that appearing on the shipping package. The certification shall note when and where all testing was done, including the rotational-capacity tests indicated herein, and shall include zinc thickness when galvanized bolts and nuts are used.

Testing to be included in the Certificate of Analysis shall be done according to the "shipping lot" method. The minimum testing required is as follows:

(1) Rotational-Capacity Test:

High strength bolts, both black and galvanized, shall be subjected to a rotational-capacity test (ASTM A 325, Section 6.2) and shall meet the following requirements when tested by the manufacturer:

(a) The tested bolts shall go through two-times the required number of turns (from snug tight conditions) indicated in the AASHTO Bridge Specification, Table 11.5B, in a Skidmore-Wilhelm Calibrator, or equivalent tension measuring device, without stripping or failure.

(b) During this test, the maximum recorded tension shall be equal to or greater than 1.15 times the Required Fastener Tension, as specified in AASHTO Table 11.5A.

(c) The measured torque to produce the Required Fastener Tension shall not exceed the value obtained by the following equation:

Torque = 0.25 PD

Where:

Torque = Measured Torque, in foot-pounds
P = Measured Bolt Tension, in pounds
D = Diameter, in feet

(2) Proof Load Tests:

Proof load tests, performed by the manufacturer, are required for the bolts (ASTM A 325) and for the nuts (ASTM A 563 or A 194). The proof load tests for nuts to be used with galvanized bolts shall be performed after galvanizing, overtapping and lubricating.

(B) Acceptance Testing:

High-strength bolts, nuts and washers will be field sampled at random by the Engineer, according to the "shipping lot" method, upon receipt of the bolt shipment by the contractor. A minimum of three bolts, with corresponding nuts and washers, or 0.1 percent of the lot, for lots in excess of 3,000, will be sampled for acceptance testing, for each bolt diameter. Samples will be submitted to ADOT Materials Group or a designated testing laboratory for the following tests:

(1) Wedge Test:

Bolts shall be tested in accordance with ASTM Test Method F 606 – WEDGE TEST METHOD as described in Section 3.5 of that standard. Fracture shall be in the body or threads of the bolt without any fracture at the junction of the head and body.

(2) Rockwell Hardness:

Rockwell hardness shall be determined in accordance with ASTM E 18 within the specified maximum shown above for bolts. Nuts and washers will only be tested for Rockwell

hardness, in accordance with ASTM E 18, to confirm compliance with ASTM A 563 or A 194 for nuts and F 436 for washers.

If any of the test bolts fail either of the above acceptance tests, the entire lot which it represents will be rejected. Similarly, if any of the nuts or washers fail the Rockwell Hardness Test, the entire lot of nuts or washers will be rejected.

(C) Installation:

All galvanized nuts shall be lubricated with a lubricant containing a visible dye so that a visual check can be made for the lubricant at the time of field installation. Black bolts must be "oily" to the touch when installed. Weathered or rusted bolts shall be cleaned and re-lubricated prior to installation.

Installation of all high strength bolts shall be in accordance with paragraph 11.5.6.4, "Installation," of the AASHTO Bridge Specifications. Of particular importance is obtaining the "snug tight" condition as defined in paragraph 11.5.6.4.4 for any method of final tightening.

A Skidmore-Wilhelm Calibrator or other acceptable bolt tension indicating device will be provided by the Department at each job site for use during bolt installation. Periodic tests (daily when calibrated wrench tightening is used) will be performed by the Department to ensure the as-installed bolt/nut/washer assembly meets the above requirements. [For short grip bolts, direct tension indicators (DTI) with solid plates may be used to perform this test. The DTI shall be checked with a longer grip bolt in the Skidmore-Wilhelm Calibrator first].

The cost of furnishing test bolts, nuts and washers will not be directly reimbursed, but will be considered incidental to the cost of related contract items.

Suitable nuts shall conform to the requirements of ASTM A 563 and suitable hardened washers shall conform to the requirements of ASTM F 436.

604-2.04 Bolts and Nuts:

Bolts and nuts shall conform to the requirements of ASTM A 307.

604-2.05 Steel Forgings:

Steel forgings shall conform to the requirements of Subsection 1004-5.

604-2.06 Castings:

Carbon steel castings, gray iron castings and malleable iron castings shall conform to the requirements of Subsection 1004-6.

604-2.07 Bronze Castings and Copper-Alloy Plates:

Bronze castings and copper-alloy bearings and expansion plates shall conform to the requirements of Subsection 1004-7.

604-2.08 Welded Stud Shear Connectors:

Shear connector studs shall conform to the requirements of ASTM A 108, Grades 1015, 1018 or 1020, and to the requirements of Section 11, Division II, Construction - Steel Structures, of the AASHTO Standard Specifications for Highway Bridges.

604-2.09 Bearing Pads:

(A) Preformed Fabric Pads:

Preformed fabric pads shall conform to the requirements of Section 1013.

(B) Elastomeric Bearing Pads:

Elastomeric bearing pads shall conform to the requirements of Section 1013.

604-2.10 Certification of Structural Steel:

Certificates of Analysis conforming to the requirements of Subsection 106.05 shall be submitted. The certificates shall include mill heat test reports showing the properties of each heat number. Mill test reports for structural steel used for those items specified in Subsection 604-2.01 shall also include the results of the Charpy V-notch impact test values.

604-3 Construction Requirements:

604-3.01 Shop and Working Drawings:

Prior to fabrication, the contractor shall prepare shop and working drawings in accordance with the requirements of Subsection 105.03.

Working drawings for steel structures shall show complete fabrication and erection details including full detailed dimensions and sizes of component parts of the structure and details of miscellaneous parts such as pins, nuts, bolts and rivets.

604-3.02 Fabrication:

Fabrication of all metal for steel structures shall be in accordance with the approved shop drawings and shall conform to the requirements of Division II, Construction, Section 11, Steel Structures, of AASHTO Standard Specifications for Highway Bridges, except as specified herein.

The structural steel fabricating plant shall be certified under the AISC Quality Certification program as follows:

Category I: Fabrication of simple or continuous rolled beam bridges.

Category III: Fabrication of all bridge structures other than simple or continuous rolled beam bridges.

Fabrication of steel components shall not begin until arrangements have been made for shop inspection.

In planing the surfaces of expansion bearings, the cut of the tool shall be in the direction of expansion.

604-3.03 Substitutions:

Substitutions of structural steel sections having different dimensions or properties of equal or greater value than those shown on the project plans may be made only when approved in writing by the Engineer.

604-3.04 Shop Inspection:

In order that shop inspection may be provided for structural steel fabrication, written notice shall be given to the Engineer at least three months prior to beginning work in the shop and the Engineer shall be verbally notified at least 24 hours prior to the need for inspection in the shop.

The contractor shall furnish all facilities for the inspection of material and workmanship in the shop in accordance with the requirements of Subsection 106.06.

Inspection at the shop is intended as a means of facilitating the work and avoiding errors and it is expressly understood that it will not relieve the contractor from any responsibility in regard to defective material or workmanship and the necessity of replacing defective material or doing the work again. Reinspection costs incurred by the Department due to contractor errors shall be reimbursed by the contractor.

604-3.05 Galvanizing:

(A) Structural Steel for bridges shall only be galvanized when specified on the project plans. When galvanizing is so specified, the members shall be galvanized in accordance with the requirements of ASTM A 123. The weight of the coating (total for both sides) shall be the weight specified.

(B) Structural Steel for minor structures and miscellaneous work shall be galvanized when specified on the project plans. When galvanizing is so specified, the members shall be galvanized in accordance with the requirements of ASTM A 123. The weight of the coating (total for both sides) shall be the weight specified.

Steel posts shall be galvanized in accordance with the requirements of AASHTO M 111 or ASTM A 123.

Steel fittings, hardware, etc., shall be galvanized, when specified, in accordance with the requirements of ASTM A 153. The weight of the coating shall be as specified in ASTM A 153.

604-3.06 Welding:

All welding and inspection of welding for structural steel except for tubular structures, shall be performed in accordance with the requirements of the ANSI/AASHTO/AWS D1.5-88 Bridge Welding Code. All other references to the American Welding Society (AWS) structural welding code AWS D1.1-80 and the AASHTO Standard Specifications for welding of structural steel highway bridges are deleted.

The use of electro-slag welding process on structural steel will not be permitted.

In addition to the above requirements, welding of Fracture Critical Members (FCMS) shall be performed in accordance with the AASHTO Guide Specifications for Fracture Critical Non-Redundant Steel Bridge Members, 1978, revised to date.

604-3.07 Painting:

All steel and iron surfaces shall be cleaned and painted in accordance with the requirements of Section 610.

604-3.08 Erection:

Erection of steel structures shall be in accordance with the requirements of Division II, Construction, Section 11, Steel Structures, of AASHTO Standard Specifications for Highway Bridges.

Straightening of bent metal members will not be permitted unless otherwise permitted by the Engineer.

604-4 Method of Measurement:

Structural steel for steel structures will be measured by the pound or will not be measured but will be paid for on a lump sum basis in accordance with the following:

(A) Weight Basis:

Unless otherwise specified, this method of measurement shall conform to the requirements of Article 11.7, Division II, Construction, Section 11, Steel Structures, of AASHTO Standard Specifications for Highway Bridges and the pay quantities of structural steel will be determined on the basis of computed net weights.

The weights of plates 36 inches or less in width will be computed on the basis of the nominal weight for their width and thickness as shown on the project plans.

(1) Structural Steel:

All rolled section girders, welded plate girders, structural steel plate or shapes used for splice plates, stiffeners or diaphragms, shear connectors, corresponding weld metal, nuts and bolts, will be measured for payment as structural steel.

(2) Structural Steel (Miscellaneous):

All other structural steel items including rockers, rollers, bearing plates, pins and nuts, brackets, plates, shapes for sign mounts on bridges, steel traffic rail, corresponding weld metal, nuts and bolts, and similar steel items not covered in other contract items will be measured for payment as structural steel (miscellaneous).

(B) Lump Sum Basis:

The project plans will show an estimated net weight of structural steel required for the structure work. This quantity shall be considered as approximate only. It shall be the responsibility of the bidder to determine the exact quantities of structural steel from computations based upon the details and notes shown on the project plans. No measurement of the quantities of structural steel determined by the contractor will be made, unless an alteration in the work is ordered. When an alteration in the work is ordered which increases or decreases the quantity of structural steel required, the amount of the increase or decrease will be measured by the pound.

604-5 Basis of Payment:

Structural steel for use in steel structures will be paid at the contract unit price per pound or at the contract lump sum price, complete in place.

When the lump sum basis of payment is specified and an alteration in the work is ordered which increases or decreases the quantity of structural steel required, a theoretical unit price, determined by dividing the lump sum bid price by the total estimated quantity of structural steel shown on the project plans, will be the basis for payment for the increase or decrease in quantity. The theoretical unit price will be subject to adjustment, all in accordance with the provisions of Subsection 104.02.

No measurement or direct payment will be made for any additional weight resulting from substitution of structural steel sections as specified in Subsection 604-3.03.

Partial payment may be made in accordance with the provisions of Subsection 109.07.

SECTION 605 STEEL REINFORCEMENT:

605-1 Description:

The work under this section shall consist of fabricating, furnishing, and placing steel reinforcement of the quality, coating, type, size, shape and quantity designated, all in accordance with the details shown on the project plans and the requirements of these specifications.

605-2 Materials:

Steel reinforcing bars, wire, and welded wire fabric shall conform to the requirements of Section 1003.

605-3 Construction Requirements

605-3.01 General:

When the project plans show a bar list and bending diagram, the contractor shall carefully check the schedule against the details in advance of ordering materials.

When bar bending diagrams are not shown on the project plans, shop drawings and lists showing the bending of reinforcement bars shall be submitted by the contractor to the Engineer for approval, but such approval shall not relieve the contractor of responsibility for the correctness of such drawings and lists.

Any discrepancy or error found by the contractor in checking a bar list or bending diagram shown on the project plans or in preparing shop drawings or lists shall be reported immediately to the Engineer, and the discrepancy or error shall be corrected in advance of fabrication and delivery of materials.

Steel reinforcement shall be protected at all times from damage. When placed in the work, all reinforcement shall be free of dirt, oil, paint and grease. Rust, surface irregularities or mill scale shall not be cause for rejection, provided the weight, dimensions, cross-sectional area and tensile properties of a manually wire brushed test specimen are not less than the requirements of these specifications.

When bending is required, it shall be done without the use of heat, and bars having cracks or splits at the bends will be rejected. Grade 40 bars which are No. 8 and larger and all sizes of Grade 60 bars shall not be rebent at the same location. Grade 40 bars which are size No. 7 and smaller may be rebent once at the same location.

Reinforcement shall be accurately fabricated and placed as shown on the plans and shall be firmly held in place by wire ties at all intersections and splices with 16 gauge or heavier tie wires and with precast mortar blocks or ferrous metal chairs, spacers, metal hangers, supporting wires or other approved supports at the spacing necessary to maintain the specified clearance of the reinforcing steel. The use of pebbles, broken stone, concrete masonry blocks, brick, metal pipe or wood blocks will not be permitted for the purpose of spacing or support. Where reinforcement spacing is less than 12 inches in each direction alternate intersections may be tied. Tack welding of reinforcement will not be permitted unless approved in writing by the Engineer. If tack welding of reinforcement is approved the reinforcement shall be deformed and shall conform to the requirements of ASTM A 706.

Before placing the pier column and superstructure reinforcement, the contractor shall insure that the vertical reinforcing steel will not interfere with the horizontal cap reinforcing steel and tendon ducts. Reinforcing steel shall not be cut to facilitate installation.

The following tolerances will be allowed when placing, tying, and supporting reinforcing steel:

In slabs and beams, horizontal bars shall be within 1/4 inch, measured vertically, of the position indicated on the plans.

In vertical walls, columns, wings, and similar members, clearance from the forms shall be within 1/4 inch of the clearance shown on the plans.

In slabs or walls, long runs of bars may vary up to two inches in spacing; however, the specified number of bars shall be placed.

No concrete shall be placed until reinforcement in the member has been inspected and approved by the Engineer. Reinforcement which does not conform to the above tolerances shall be adjusted or repaired prior to concrete placement.

When required by the project plans, all reinforcement and all other steel elements to be encased in the concrete of a bridge deck or bridge barriers shall be epoxy coated. Reinforcement that is to be partially within these concrete elements, but extends into other structural elements, will not require coating on that part which is to be outside the bridge deck or bridge barrier concrete.

605-3.02 Splicing and Lapping:

All reinforcement shall be furnished in the full lengths indicated on the project plans. Splicing of bars, except as shown on the plans, will not be permitted without the Engineer's approval. Splices shall be staggered as far as possible. The type and method of splices or connections shall be approved by the Engineer.

The contractor may use either lap splices, full welded splices or mechanical connections for reinforcement bars up to and including bar size No. 11. Where the bar size exceeds No. 11, full welded splices or mechanical connections shall be used. Welded splices shall not be used on epoxy-coated bars, and no welding shall be performed close enough to epoxy-coated bars to cause any heating of the coating. All exterior surfaces of positive connectors for epoxy-coated bars shall have the same coating as the bar.

In lapped splices, the bars shall be placed in contact with one another and wired together in such a manner as to maintain a clearance of not less than the minimum clear distance to other bars and the minimum distance to the surface of the concrete, as specified in the AASHTO Standard Specifications for Highway Bridges. Lap lengths shall be as shown on the plans.

A full welded splice is one in which the bars are butted and welded to develop, in tension, at least 125 percent of the specified yield strength of the bar. Test requirements shall be as specified in AWS D 1.4.

Welding shall be performed in accordance with the requirements of Subsection 604-3.06.

A mechanical connection is one in which the bars are connected to develop an ultimate strength, in tension or compression as required, of at least 125 percent of the specified yield strength of the bar.

Except as otherwise specified, mechanical splices shall be made in accordance with the manufacturer's recommendations as approved by the Engineer. As a condition of approval, the contractor shall make three test splices in the presence of the Engineer of each size it intends to splice. Two of the test splices shall be tension tested to 125 percent of the specified yield strength of the bar and one splice shall be tested to destruction by an approved laboratory and certified reports of the tests shall be submitted to the Engineer for approval. Field splices shall be subject to visual inspection and physical testing. A minimum of two percent of the field splices chosen at random by the Engineer shall be removed and tested to 125 percent of specified yield strength by the Engineer. Samples shall be at least 42 inches long with the splice at mid length.

Sheets of welded wire fabric or bar mat reinforcement shall overlap each other sufficiently to maintain a uniform strength and shall be securely fastened at the ends and edges. The edge lap shall not be less than one mesh width.

605-3.03 Epoxy-Coated Reinforcement:

(A) General:

The requirements of this subsection for epoxy-coated reinforcement are in addition to the previous requirements which apply to un-coated reinforcement.

(B) Field Operations - Epoxy-Coated Bar Reinforcement:

All handling systems for coated bars shall have padded contact areas for the bars wherever possible. All bundling bands shall be padded and all bundles shall be lifted with a strong back, multiple supports or a platform bridge so as to prevent bar to bar abrasion from sags in the bar bundle. The bars or bundles shall not be dropped or dragged.

All hardware that will remain permanently in concrete using epoxy coated reinforcement shall be made of or coated with a dielectric material. Such hardware includes reinforcement chairs, tie wires, screed rail supports, or any other item that would be a potential source of corrosion. The specific hardware that the contractor proposes to use shall be approved by the Engineer.

The contractor shall be required to field repair damaged areas of the coating, and to replace items exhibiting severely damaged coatings. The material used for field repair shall be that supplied by the coating applicator.

Field repair shall be required wherever the area of coating damage exceeds two percent of the surface area of the bar in a one-foot length and the damaged spot is larger than 1/4- by 1/4-inch.

Field repair will not be allowed on bars which have severely damaged coatings. A severely damaged coating is defined as a coating which has a total damaged area greater than five percent of the surface area of the reinforcing bar. The Engineer shall be the sole determiner of the severity of damaged area for purposes of repair or replacement. A reinforcing bar having a coating determined by the Engineer to be severely damaged shall not be incorporated in the work and it shall be removed from the work site. All such bars shall be replaced in kind by the contractor at no additional cost to the Department.

605-3.04 Dowel Placement:

Dowel placement shall consist of drilling or coring dowel holes, furnishing and placing setting materials and placing metal dowels in accordance with the details shown on the plans and the requirements of the specifications.

The diameter of dowel holes shall be 1/4 inch larger than the diameter of the dowels to be placed and the depth of the holes shall be as shown on the plans.

Setting materials shall be an approved epoxy adhesive unless otherwise specified on the plans.

The minimum tensile pull out strength of the dowel anchorage shall be as specified on the plans.

If required by the Engineer, the contractor shall submit details of the anchorage system to the Engineer prior to dowel placement.

605-4 Method of Measurement:

605-4.01 General:

No measurement for payment will be made for steel reinforcement, whether coated or uncoated as required, which is included in a precast concrete item which is listed in the bidding schedule as a unit to be paid for at a lump sum price.

Steel reinforcement that is required on the plans to be epoxy-coated for use in bridge concrete and that is partially within the deck, yet projects into other structural elements, shall be included in the measurement and payment for Reinforcing Steel (Epoxy Coated). The contractor is required to coat only that part of the reinforcement that is contained in the deck or concrete bridge barriers.

Except for that contained in a precast concrete item to be measured as a unit, steel reinforcement will be measured as a lump sum item or by the pound, as listed in the bidding schedule. Epoxy-coated reinforcement will be measured separate from un-coated reinforcement.

Dowel placement will be measured by the unit each.

605-4.02 Lump Sum Basis:

The project plans will show an estimated net weight of reinforcing steel required for the work. This quantity shall be considered as approximate only. It shall be the responsibility of the bidder to determine the exact quantities of all reinforcing steel required, by computations based upon the details and notes shown on the project plans. It is understood that the quantities of all reinforcing steel required for the work shall be furnished by the contractor, including samples for testing. Measurement of the quantity furnished will be made either when an alteration in the work is ordered or when evidence shows or there is good reason to believe that the actual quantity of reinforcing steel varies from the total quantity shown on the project plans by three percent or more. When an alteration in the work is ordered or when the quantity varies as herein specified, the actual quantity of reinforcing steel will be computed by the Engineer and the amount of the increase or decrease will be measured by the pound.

605-4.03 Weight Basis:

Reinforcing Steel will be measured in pounds based on the total computed weight for the size and lengths of bars, wire or welded wire fabric as shown on the plans or authorized.

The weight of bars will be calculated from weight shown in Table 605-1.

The weight of welded wire fabric will be computed from the theoretical weight of plain wire of the corresponding gauge. If the weight per square foot is shown on the plans, that weight will be used.

In measurement of the weight of epoxy-coated steel reinforcement, no addition to or deduction from the weights shown in Table 605-1 will be made because of additional requirements for blast cleaning and epoxy coating.

When laps are made for splices other than those shown on the plans for the convenience of the contractor, the extra steel will not be included in the measurement for payment.

The measurement of samples for testing will be the weight in pounds of the samples selected by the Engineer or the weight in pounds of the full length of reinforcing steel bars supplied for sampling purposes when sampling is done at the construction site.

TABLE 605-1

Deformed Bar Designation No.	Weight, pounds per linear foot	Nominal Diameter, inches
3	0.376	0.375
4	0.668	0.500
5	1.043	0.625
6	1.502	0.750
7	2.044	0.875
8	2.670	1.000
9	3.400	1.128
10	4.303	1.270

TABLE 605-1		
Deformed Bar Designation No.	**Weight, pounds per linear foot**	**Nominal Diameter, inches**
11	5.313	1.410
14	7.650	1.693
18	13.600	2.257
Note: The nominal diameter of a deformed bar is equivalent to the diameter of a plain round bar having the same weight per foot as the deformed bar. Bar numbers are based on the number of eighths of an inch included in the nominal diameter of the bars.		

605-5 Basis of Payment:

The accepted quantities of Reinforcing Steel, of the type shown in the bidding schedule, measured as provided above, will be paid for at the contract lump sum price or the contract unit price per pound, complete in place.

The lump sum price or unit price per pound shall also include the cost of chairs, supports, fasteners, connections, tie wire, and any splices not specifically shown on the plans. If the Engineer permits the substitution of larger bars than those specified or splices not shown on the plans payment will be made only for the amount of steel which would have been required if the specified size and length had been used.

The accepted quantity of dowels placed, measured as provided above, will be paid for at the contract unit price, which price shall be full compensation for the work complete in place. Steel reinforcement furnished for dowels will be measured and paid for under the Reinforcing Steel item.

No measurement or direct payment will be made for furnishing and placing dowels which are required to replace existing reinforcing steel that is damaged as a result of the contractor's operations.

SECTION 606 OVERHEAD SIGN STRUCTURES:

606-1 Description:

The work under this section shall consist of furnishing and installing overhead sign structures in accordance with the details shown on the plans and in accordance with the requirements of these specifications.

Sign structures shall be of the following types: bridge truss, cantilever truss, tubular overhead, tubular cantilever, bridge tapered tube single beam, cantilever tapered tube double arm, and sign attachment structure for existing bridge. The type of sign structure to be installed at each location will be shown on the project plans.

606-2 Materials:

606-2.01 General:

Certificates of Analysis conforming to the requirements of Subsection 106.05 shall be submitted for all structural steel. Mill test reports for structural steel used as specified under Subsection 606-2.02 shall include the results of the Charpy V-notch impact test values.

606-2.02 Structural Shapes, Plates and Bars:

Shapes, plates and bars for trusses, columns and walkway assemblies of the sign structures shall be fabricated from structural steel conforming to the requirements of ASTM A 36.

Structural steel used for the fabrication of column or girder flanges, web plates and truss chord angles shall be in accordance with longitudinal Charpy V-notch impact test values specified in Subsection 604-2.01.

606-2.03 Tapered Tubes:

Tapered tube beams, arms and poles for the bridge single beam sign structures and for the cantilever double arm sign structures shall be fabricated from structural steel conforming to the requirements of ASTM A 595, Grade A.

606-2.04 Pipe Poles for Cantilever Truss:

Poles shall be welded or seamless steel pipe conforming to the requirements of ASTM A 53, Type E or S, Grade B.

606-2.05 Bolts, Nuts and Washers:

High-strength steel bolts, nuts and washers shall conform to the requirements of ASTM A 325. All other bolts and nuts shall conform to the requirements of ASTM A 307, and shall be furnished with commercial quality washers.

Anchor bolts for the sign foundations shall conform to the requirements of ASTM A 36.

All bolts, nuts, and washers, except high-strength bolts and anchor bolts, shall be cadmium plated in accordance with the requirements of ASTM B 766 or zinc plated in accordance with the requirements of ASTM B 633.

606-2.06 Concrete:

Concrete for all sign structure foundations shall be Class S (f'_c = 3,000 pounds per square inch) conforming to the requirements of Section 1006.

606-2.07 Reinforcing Steel:

Reinforcing steel bars shall conform to the requirements of ASTM A 615, Grade 40. Reinforcing steel wire shall conform to the requirements of ASTM A 82.

606-2.08 Nonshrink Grout:

Nonshrink grout shall conform to the requirements of the Corps of Engineers Specification for Nonshrink Grout CRD-C 621 and shall be approved be the Engineer. Grout shall be mixed, handled and placed in accordance with the manufacturer's recommendations.

606-3 Construction Requirements:

606-3.01 Shop Drawings:

The contractor shall furnish shop drawings for approval by the Engineer prior to fabrication of the sign structure material. Shop drawings shall be furnished in accordance with the requirements of Subsection 105.03. The foundation shall be set at the elevation called for in the project plans and the embankment graded to match the top of the foundation as directed by the Engineer.

606-3.02 Fabrication:

Fabrication of component parts of the sign structures shall be in accordance with the approved shop drawings and shall conform to the requirements of Division II, Construction, Section 11, Steel Structures, of the AASHTO Standard Specifications for Highway Bridges.

606-3.03 Welding:

Welding of tubular structural steel shall conform to the requirements of Section 10 of AWS D1.1-80, Structural Welding Code, of the American Welding Society. The welding of all other structural steel shall conform to Subsection 604-3.06.

606-3.04 Galvanizing:

All steel surfaces of sign structures shall be galvanized after fabrication. Galvanizing shall conform to the requirements of ASTM A 123 and A 153.

606-3.05 Foundations:

Reinforced concrete foundations for the sign structures shall be constructed to conform to the details shown on the plans and in accordance with the requirements of Subsection 609-1 through 609-3.

Concrete shall be placed, finished and cured in accordance with the requirements of Section 601.

606-4 Method of Measurement:

Overhead sign structures will be measured by the unit of each type or types of sign structures furnished and erected.

Foundations for the sign structures will be measured by the unit of each type or types of foundations constructed.

606-5 Basis of Payment:

The accepted quantities of various types of overhead sign structures and foundations, measured as provided above, will be paid for at the contract unit prices complete in place.

The contract unit price paid per unit for each type and size of sign structure designated in the bidding schedule shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all the work involved in furnishing and erecting the sign structures complete in place, including painting, galvanizing if necessary, furnishing and placing nonshrink grout, furnishing tapered tube sign mounting brackets, and all necessary hardware except for anchor bolts which are considered as part of the foundations, all as shown on the plans and as specified in these specifications.

The contract unit price for each type of sign structure foundation designated in the bidding schedule shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all the work involved in constructing foundations, complete in place, including steel reinforcement, furnishing and installing anchor bolts, all necessary excavation, backfilling and disposing of excess excavated material, all as shown on the plans and as specified in these specifications.

SECTION 607 ROADSIDE SIGN SUPPORTS:

607-1 Description:

The work under this section shall consist of furnishing and installing roadside sign supports in accordance with the details shown on the plans and the requirements of these specifications.

Sign supports shall consist of breakaway, perforated and U-channel sign posts. The type, size and installation location of the sign posts will be shown on the project plans.

607-2 Materials:

607-2.01 General:

Certificates of Analysis conforming to the requirements of Subsection 106.05 shall be submitted for breakaway sign post shapes

Certificates of Compliance conforming to the requirements of Subsection 106.05 shall be submitted for perforated sign posts and U-channel sign posts.

607-2.02 Breakaway Sign Post Shapes:

Posts shall be fabricated from structural steel conforming to the requirements of ASTM A 572, Grade 50 or ASTM A 588 at the option of the contractor. Base plates for the

breakaway connections and friction fuse plates and back plates for the post hinge assembly shall be fabricated from the same type structural steel selected for the sign posts.

All plate holes shall be drilled and all plate notches shall be saw cut, except that flame cutting will be permitted provided all edges are ground. Flange holes shall be drilled or sub-punched and reamed. The posts shall be saw cut for the hinge and bolted as detailed on the plans.

Bolts, nuts and washers shall conform to the requirements of ASTM A 325.

Posts and plates shall be galvanized after fabrication in accordance with the requirements of ASTM A 123. Bolts, nuts and washers shall be cadmium plated in accordance with the requirements of ASTM B 766, or zinc plated in accordance with the requirements of ASTM B 633.

607-2.03 Perforated Sign Posts:

Single and telescoping perforated posts shall be square tube fabricated from galvanized sheet steel. The sheet steel shall have a thickness of 0.105 inches (12 gauge) or 0.135 inches (10 gauge) as required by the project specifications. Sheet steel shall conform to the requirements of ASTM A 653 for either SQ Grade 40 or SQ Grade 50 Class 1, and be galvanized in accordance with the requirements of Coating Designation G-90. The posts shall have a wall thickness, including coating, of 0.097 to 0.116 inches for 12 gauge and 0.127 to 0.146 inches for 10 gauge.

Posts shall be welded directly in the corner by high frequency resistance welding or equal. The outside edges of the posts shall be scarfed as necessary to produce a standard corner radii of 5/32 ± 1/32 inch.

External welded surfaces and scarfed areas shall be re-galvanized after fabrication.

Holes 7/16 ± 1/64 inch in diameter shall be provided on one-inch centers along all four sides over the entire length of the post. The holes shall be laterally centered on the longitudinal centerline of each face. Hole positioning and spacing shall be the same on all four faces, such that the hole centerlines for each group of four holes shall pass through a common point on the longitudinal centerline of the tube. For telescoping posts, holes shall be in proper alignment to allow 3/8-inch diameter bolts to pass through the entire post.

The finished posts shall be straight and have a smooth, uniform finish. All consecutive sizes of posts shall be freely telescoping for not less than 10 feet of their length without the necessity of matching any particular face to any other face.

Perforated sign posts shall be manufactured by an approved manufacturer. A list of approved manufacturers of perforated sign posts is shown on the Department's Approved Products List (APL). Copies of the most current version of the APL are available on the internet at http://www.dot.state.az.us/ABOUT/atrc/apl.htm.

Bolts shall conform to the requirements of SAE Specification J 429, Grade 5, or ASTM A 449, Type 1. Nuts shall conform to the requirements of ASTM A 563, Grade A. Washers shall conform to the requirements of ASTM F 844.

Bolts, nuts and washers shall be zinc coated in accordance with the requirements of ASTM B 633 or cadmium plated in accordance with the requirements of ASTM B 766.

607-2.04 U-Channel Sign Posts:

U-channel posts shall be fabricated from rerolled rail steel or hot-rolled carbon steel bars.

Prior to rerolling the rail steel, the rail nominal weight shall be 91 pounds per yard and shall meet the requirements of ASTM A 1 pertaining to quality assurance.

Yield Point of the steel shall be 80,000 pounds per square inch minimum.

The cast heat analysis of the steel shall conform to the following requirements:

Element	Composition (Percent)
Carbon	0.67 - 0.82
Manganese	0.70 - 1.10
Phosphorus: Max.	0.04
Sulfur: Max.	0.05
Silicon	0.10 - 0.25

Posts shall be a uniform, modified, flanged channel-section as shown in the plans. Weight of the posts shall be three pounds per lineal foot, plus or minus five percent. The post shall be punched with continuous 3/8-inch diameter holes on one-inch centers. The first hole shall be one inch from top and bottom of post.

The post shall consist of two parts, a sign post and a base post. The sign post lengths shall be supplied in six-inch increments up to 12 feet as required for the installation location. The base posts shall be 42 inches in length, pointed at one end, and have at least eighteen holes in the base post, starting one inch from the top and continuing at one-inch increments.

Posts shall be machine straightened to have a smooth uniform finish, free from defects affecting their strength, durability, or appearance. All holes and rough edges shall be free from burrs. The permissible tolerance for straightness shall be within 1/16 inch in three feet.

Posts shall be galvanized after fabrication in accordance with the requirements of ASTM A 123. Bolts, nuts, washers and spacers shall be cadmium plated in accordance with the requirements of ASTM B 766 or zinc plated in accordance with the requirements of ASTM B 633.

For shipment, the posts shall be nested and fastened in such a manner that they will not slip. Care shall be taken during shipping to minimize the rubbing of posts together resulting in damage to the galvanized finished surface. Excessive damage to the finish of the posts

during shipping or handling will result in rejection of the damaged posts. Posts shall be bundled in groups of no more than 100.

U-channel base posts shall be driven into the ground to a depth of 38 inches. Where rock is encountered, the rock shall be cored, drilled or removed to a minimum diameter of eight inches and to a depth sufficient to place Portland cement concrete two inches below the bottom of the base post and fill the hole to within one inch of the top. Solid rock coring or drilling is not required to continue beyond 24 inches in depth regardless of the depth at which the rock is encountered. The base post may be cut at the bottom prior to being set in Portland cement concrete where rock does not permit use of full length base post.

607-2.05 Concrete:

Concrete for breakaway sign post foundations shall be Class B, except that utility concrete may be used for foundations using stub post sizes S 3 x 5.7 and S 4 x 7.7. Class B concrete shall conform to the requirements of Section 1006 and utility concrete to the requirements of Section 922. Concrete for perforated sign posts foundations and U-channel sign post foundations, when required, shall conform to the requirements of Subsections 922-2 and 922-3.

Foundation stub posts shall be fabricated from the same type of steel selected for the appropriate sign posts. Breakaway stub posts shall be galvanized a minimum of 12 inches down from the top of the stub. Galvanizing shall be in accordance with the requirements of ASTM A 123.

Reinforcing steel bars for breakaway sign post foundations shall conform to the requirements of ASTM A 615, Grade 40. Reinforcing steel wire shall conform to the requirements of ASTM A 82.

607-3 Construction Requirements:

Fabrication of the breakaway sign posts, stub posts and base plates shall conform to the requirements of Subsection 604-3.02, except that shop drawings will not be required.

Breakaway sign post lengths will be determined by the Engineer at the time of construction staking and will be furnished to the contractor prior to ordering fabrication of the sign posts.

Perforated and U-channel sign post lengths shall be determined by the contractor at the time of construction staking. Posts shall be cut to the proper lengths in the field. Splicing will be permitted for single perforated posts; however, splices will be limited to one per each post installation and the splicing shall be accomplished in accordance with the details shown on the plans. The minimum length of any spliced piece of post shall be two feet.

Foundations for the breakaway sign posts, perforated sign posts and when required, U-channel posts shall be constructed to the details and dimensions shown on the plans. Concrete shall be placed in accordance with the requirements of Section 601 or 922, as the case may be. Excavation shall conform to the requirements of Subsection 203-5.03(A).

Sign posts shall be erected plumb and shall be bolted to the foundation stub or base posts in accordance with the procedure specified on the plans.

607-4 Method of Measurement:

Breakaway sign posts will be measured by the linear foot for each size of post furnished and erected. The length of each size of post will be measured from the bottom of the upper base plate to the top of the post, measured to the nearest 0.1 feet. The total length of all posts of the same size will be rounded to the nearest foot.

Perforated sign posts will be measured by the linear foot of each type of post furnished and installed. The length of each type of post will be measured from the top of the concrete post foundation to the top of the post, measured to the nearest 0.1 feet. The total length of all posts of the same type will be rounded to the nearest foot. Telescoping post members will be considered as one post after installation and will not be measured separately. U-channel posts will be measured as each.

Foundations for signposts will be measured by the unit for each type of foundation constructed, except that concrete and excavation, when required for setting U-channel base posts, will be considered as part of the post.

607-5 Basis of Payment:

The accepted quantities of breakaway posts, perforated posts, U-channel posts and foundations for the sign posts, measured as provided above, will be paid for at the contract unit prices complete in place.

The contract unit price paid per linear foot for each size of breakaway sign post, each type of perforated sign post and each installation of U-channel post designated in the bidding schedule shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all the work involved in furnishing and erecting the sign posts, complete in place, including galvanizing and furnishing all metal plates and hardware, all as shown on the plans and as specified herein.

The contract unit price paid per unit for each type of sign foundation designated in the bidding schedule shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all the work involved in constructing foundations, complete in place, including the steel stub posts, lower base plate and steel reinforcement (except for stub posts S 3 x 5.7 and S 4 x 7.7) for the breakaway sign post foundation; the portion of perforated post within the foundations; galvanizing the posts; and excavation, all as shown on the plans and as specified herein.

SECTION 608 SIGN PANELS:

608-1 Description:

The work under this section shall consist of furnishing and installing sign panels in accordance with the details shown on the plans and the requirements set forth herein.

The sign panels shall be of the following types:

- Extruded Aluminum Sign Panels With Demountable Characters
- Overhead Sign Panels
- Overlaid Sign Panels
- Flat Sheet Aluminum Sign Panels With Demountable Characters
- Flat Sheet Aluminum Sign Panels With Direct-Applied or Silk-Screened Characters
- Overlaid Plywood Sign Panels With Direct-Applied or Silk-Screened Characters
- Warning, Marker, and Regulatory Sign Panels
- Route Shields for Installation on Sign Panels
- EXIT ONLY for Installation on Sign Panels

608-2 Materials:

608-2.01 General:

Certificates of Compliance, conforming to the requirements of Subsection 106.05, shall be submitted for all materials required for fabricating sign panels, including retroreflective sheeting.

Shipment, storage, and handling of sign panels shall conform to the recommendations of the manufacturers of the sign panel components. Fabricated signs and overlay sheets shall be shipped on edge. Damage to the sign panel or legend resulting from banding, crating or stacking may be cause for rejection of the signs.

Characters shall not be attached to overlay sheets during shipment.

608-2.02 Extruded Aluminum Sign Panels With Demountable Characters:

Panels shall be fabricated from 12-inch wide aluminum extrusions formed from Aluminum Alloy 6063-T6 conforming to the requirements of ASTM B 221 and fastened together by bolt connections as shown on the plans.

Panel facing shall be covered with retroreflective sheeting of the color specified on the plans. The retroreflective sheeting shall conform to the requirements of Section 1007.

The letters, numerals, symbols, borders and other features of the sign message shall conform to the requirements of Subsection 608-2.14, Demountable Characters.

Panel surfaces to be covered with retroreflective sheeting shall be prepared in accordance with the recommendations of the sheeting manufacturer. Panel surfaces not covered with sheeting shall be etched in accordance with the recommendations of the extrusion manufacturer to reduce glare from reflected sunlight.

After all fabrication has been completed, including the cutting and punching of holes, except holes for demountable letters, numerals, symbols and borders, the aluminum extrusions shall be degreased and the retroreflective sheeting shall be applied.

Aluminum extrusions shall be flat with 1/4 inch of tolerance allowed in an eight-foot length, with proportionally greater tolerances permitted on lengths greater than eight feet. Flatness tolerance across the face of each extrusion shall be 0.5 percent of the width.

Aluminum extrusions shall be bolted together on 12-inch centers with a maximum allowable gap of 1/32 inch between extrusions.

Shop fabricated sub-assemblies shall be rigidly braced for transportation and erection. Hardware utilized to fasten panels to supports shall conform to the panel manufacturer's recommendations.

Each completed sign panel shall be provided with a side trim molding fabricated from extruded Aluminum Alloy 6063-T6 conforming to the requirements of ASTM B 221. The trim molding shall be fastened to each individual 12-inch aluminum extrusion with two 5/32-inch diameter self-plugging aluminum blind rivets, 2-1/2 inches from either edge. The exposed surface of the side trim molding shall be treated by etching as recommended by the manufacturer to reduce glare from reflected sunlight.

Each completed sign panel shall be shipped with sufficient bolt clamps placed to install the panel on the sign posts as shown in the plans. Bent bolt channels will be cause for rejection of the sign panel.

608-2.03 Blank

608-2.04 Overhead Sign Panels:

Panels, except Warning and Regulatory Sign Panels, installed over traffic lanes or shoulders on Overhead Sign Structures shall consist of overlaying new extruded aluminum sign panels. The extruded aluminum sign panel substrate shall conform to the requirements specified in Subsection 608-2.02, except that retroreflective sheeting shall not be applied. The new panels shall be prepared as specified in Subsection 608-2.05, Overlaid Sign Panels.

The letters, numerals, symbols, borders and other features of the sign message shall conform to the requirements of Subsection 608-2.14, Demountable Characters.

The panels shall be shop fabricated and shipped complete or as sub-assemblies with the overlay panels and characters rigidly attached.

Shop-fabricated sub-assemblies shall be rigidly braced for transportation and erection. Hardware utilized to fasten panels to shipping braces shall conform to the panel manufacturer's recommendations.

608-2.05 Overlaid Sign Panels:

(A) General:

Panels shall be fabricated by attaching three- and four-foot widths of 0.063-inch thick, 5052-H38 aluminum overlay sheets to new or existing sign panel substrates, as called for in the plans. The sheets shall be equal in length to the height of the sign to which applied.

One surface of the overlay sheet shall be prepared and covered with retroreflective sheeting, conforming to the requirements of Section 1007, in accordance with the recommendations of the reflective sheeting manufacturer. The color of sheeting shall be as called for in the plans. The retroreflective sheeting on overlay sheets for each sign panel shall be color matched and shall be from the same manufacturing lot and run.

Panels having a minimum dimension not greater than four feet shall be overlaid with a one-sheet overlay with no splices.

All rivets used shall be 5/32-inch diameter self-plugging aluminum blind rivets. Rivets shall be anodized to the color of the sign panel face, border or letter in which they are placed except that, when placed in white, plain silver rivets may be used. Rivets placed in the characters shall be shoulder rivets at least 3/4 inch in length. Rivets placed in the panel face shall be straight rivets at least 1/2 inch in length. All rivets shall extend through the panel face and be set tight.

(B) Overlaying Existing Sign Panels:

When the plans call for overlaying existing sign panels, the panels may be overlaid using any of the following procedures:

(1) In place on the existing posts. If the signs are overlaid in place, the contractor shall not place ladders against the face of the new sign sheeting or use other devices that might be detrimental to the new surface.

(2) By removing the panels from the existing supports or by detaching the existing supports at the base or hinge plate and transferring the existing sign to a truck with a framework of sufficient size to provide complete back bracing for the sign panel while holding it in an erect, or nearly erect, position. The framework may be inclined at an angle not to exceed 20 degrees from the vertical. If the panels are removed from the existing supports, they shall be braced on the back by attaching the panels with post clamps to steel shapes of equal or greater weight than that of the existing supports.

(3) By detaching the existing supports at the base or hinge plate, placing the sign structure on the ground face up and supporting it by dunnage such that the panel is rigidly held and uniformly supported to prevent twisting or distortion.

(4) By removing the existing sign panel from its supports and transferring it to a central plant or workshop where the overlay may be accomplished. During the overlaying process, the sign panel shall be placed on a stable, level working platform that fully supports the sign panel so that no twisting or distortion may take place.

If either method (3) or (4) above is utilized, the contractor shall take such measures as are necessary to ensure that adequate tension is placed on the overlay sheets during installation to prevent bubbles, ripples, or other distortions in the sign panel surface from occurring when the signs are erected.

Existing embossed borders and sign message characters and any prior overlays shall be removed by drilling through the heads of the mounting rivets or by shearing the rivets with a flathead shovel or trowel.

Edge trim moldings do not require removal unless the plans call for modifying the panel, in which case the edge moldings shall be removed and replaced with new edge molding. Existing characters shall not be reused.

Before overlaying, holes, dents and minor bent sections of existing substrate panels shall be flattened with a hammer so that the sign face is free of projections or large indentations.

Overlay sheets shall be installed as shown in the plans, one at a time, on the substrate panels, starting at the side farthest from the roadway center line, approximately one inch in from the edge. The overlay sheets shall be fastened at the top edge with three aluminum blind rivets: one at the center, and one between three and four inches from each side. Working from top to bottom, a single row of rivets, approximately one foot apart, shall be installed down the center of the overlay sheet. New legend and border shall then be installed, as indicated on the sign format drawings in the plans. Existing copy shall not be reused.

The remaining overlay sheets shall be installed in the same manner, except that rivets shall also be installed at one-foot intervals along the lap spliced joint between adjacent sheets in the same sequence as described above. After all border and copy are installed, all open edges on the panels shall be riveted at approximately one-foot intervals.

Overlay sheets shall be stored as described in Subsection 608-2.01.

608-2.06 Flat Sheet Aluminum Sign Panels With Demountable Characters:

Panels shall be fabricated from one-piece, 0.125-inch thick, 5052-H38 Aluminum Alloy conforming to the requirements of ASTM B 209.

Panel facing shall be prepared and covered with retroreflective sheeting in accordance with the recommendations of the sheeting manufacturer. The color shall be as specified on the plans or as shown in the ADOT Manual of Approved Signs.

All surfaces not covered shall be etched to reduce glare from reflected sunlight.

The retroreflective sheeting shall conform to the requirements of Section 1007. Splicing of retroreflective sheeting shall not be allowed on sign panels having a minimum dimension up to and including four feet.

The letters, numerals, symbols, borders and other features of the sign message shall conform to the requirements of Subsection 608-2.14, Demountable Characters.

608-2.07 Flat Sheet Aluminum Sign Panels With Direct-Applied or Silk-Screened Characters:

Panels shall be fabricated from 0.125-inch thick, 5052-H38 Aluminum Alloy conforming to the requirements of ASTM B 209.

Panel facing shall be prepared and covered with retroreflective sheeting in accordance with the recommendations of the sheeting manufacturer. The color of the sheeting shall be as specified on the plans or as shown in the Manual of Approved Signs.

All surfaces not covered shall be etched to reduce glare from reflected sunlight.

The retroreflective sheeting shall conform to the requirements of Section 1007. Splicing of retroreflective sheeting shall not be allowed on sign panels having a minimum dimension up to and including four feet.

Messages shall be reflectorized white or, if called for on the plans, opaque black and shall be produced by either silk screening or direct-applying lettering as specified under Subsection 608-2.15.

608-2.08 Overlaid Plywood Sign Panels With Direct-Applied or Silk-Screened Characters:

Panels shall consist of 5/8-inch thick, medium-density overlaid Douglas Fir grade A-A or B-B plywood conforming to the requirements of Product Standard PS-1 published by the American Plywood Association and the U.S. Department of Commerce. The medium density overlay shall consist of a smooth resin-fiber surface of beater-loaded CreZon with phenolic formaldehyde resin content not less than 17 percent by weight. Each CreZon sheet shall weigh not less than 58 pounds per 1,000 square feet of single face. The thickness of the overlay shall be not less than 0.012 inches after application.

The back of the sign panels shall be covered with two coats of light gray enamel (Color Chip No. 36187) conforming to the requirements of Section 1002.

The edges of the sign panels shall be coated with a pigmented phenolic varnish matching the color of the back of the sign. Color match will be by visual inspection.

The retroreflective sheeting shall conform to the requirements of Section 1007. The color shall be as called for in the plans or as shown in the Manual of Approved Signs. Splicing of retroreflective sheeting shall not be allowed on signs having a minimum dimension up to and including four feet.

Messages shall be reflectorized white or, if called for on the plans, opaque black and shall be produced by either silk screening or direct-applying characters, as specified under Subsection 608-2.15.

Panels shall be attached to the posts with 5/16-inch diameter elevator bolts with a flat washer and two hex nuts on the back.

608-2.09 Warning, Marker, and Regulatory Sign Panels:

Panels shall be fabricated from flat sheet aluminum and shall be reflectorized as specified herein.

Panels shall be fabricated in one piece from 0.125-inch thick, 5052-H38 or 6061-T6 Aluminum Alloy conforming to the requirements of ASTM
B 209.

All surfaces of panels to be covered with retroreflective sheeting shall be prepared in accordance with the recommendations of the sheeting manufacturer. Surfaces not covered shall be etched to reduce glare from reflected sunlight. Retroreflective sheeting shall conform to the requirements of Section 1007.

Warning signs shall be reflectorized with yellow retroreflective sheeting.

Regulatory signs shall be reflectorized with silver-white retroreflective sheeting.

Reflectorized red signs shall be reflectorized with silver-white retroreflective sheeting. The red color shall be produced by silk screening.

Regulatory signs with reflectorized red circles and slashes shall be reflectorized with silver-white retroreflective sheeting. The red color shall be produced by silk screening.

Interstate route markers shall be cut to shape. The colors and legend shall be as shown on the plans and shall be reflectorized with silver-white retroreflective sheeting. The Interstate route colors shall be silk screened. The numerals may be silk-screened or direct-applied characters.

United States, State Route, and Cardinal Direction markers shall be reflectorized with silver-white retroreflective sheeting unless otherwise shown on the plans.

Splicing of retroreflective sheeting shall not be allowed on sign panels having the minimum dimension up to and including four feet.

Sign panels shall be attached to the posts with bolts as shown in the plans. A nylon washer, conforming to ANSI Standard and having a diameter two times the bolt head diameter, shall be placed between the bolt head and panel face. Fastening nuts shall be heavy hex; however, standard nuts may be used if a flat wash is placed between the nut and sign posts.

608-2.10 Blank

608-2.11 Route Shields (For Installation on Sign Panels):

Route shields shall be cut to shape and shall consist of 0.063-inch thick, 5052-H38 Aluminum Alloy conforming to the requirements of ASTM B 209. The aluminum shall be degreased and etched in accordance with the recommendations of the sheeting manufacturer. Retroreflective sheeting shall be silver-white and shall conform to the requirements of Section 1007. The size of the numerals shall be half the height of the shield.

Route shields shall be attached to the sign panel with self plugging aluminum blind rivets with a 1/4-inch thick nylon spacer on each rivet between the route shield and the sign panel.

608-2.12 EXIT ONLY (For Installation on Sign Panels):

EXIT ONLY panels shall be fabricated from 0.063-inch thick, 5052-H38 Aluminum Alloy conforming to the requirements of ASTM B 209 with yellow retroreflective sheeting adhered to the face side. The aluminum shall be degreased and etched in accordance with the recommendations of the sheeting manufacturer. Retroreflective sheeting shall conform to the requirements of Section 1007.

EXIT ONLY panels shall be attached to the sign panel with self-plugging aluminum blind rivets with a 1/4-inch thick nylon spacer on each rivet between the EXIT ONLY panel and the sign panel.

The letters, arrows, and borders shall consist of black embossed aluminum frames or flat sheet aluminum frames with no reflectors. The height of the letters shall be 12 inches unless otherwise specified in the plans. The panel shall be 36 inches in height unless otherwise specified in the plans.

608-2.13 Retroreflective Sheeting:

Retroreflective sheeting shall conform to the requirements of Section 1007.

The colors specified for retroreflective sheeting shall match visually and be within the color tolerance limits shown on the appropriate Highway Color Tolerance Charts issued by the Federal Highway Administration.

608-2.14 Demountable Characters:

The letters, numerals, symbols, borders, and other features of the sign message shall consist of embossed aluminum frames in which prismatic reflectors are installed so as to be an integral part of the character or otherwise affixed to prevent their displacement in handling or service. Reflectors that are held in the frames by means of tape or adhesive will not be accepted. All items shall be fabricated from 0.040-inch thick sheet Aluminum Alloy 3003-H14, conforming to ASTM B 209. Mounting holes shall be provided within frames to permit the use of screws, rivets, or other common fasteners. The size and spacing of reflector holes shall be such as to afford maximum night legibility and visibility to the finished cut-out figure. The reflectors shall conform to the requirements of Section 1008. The embossed aluminum frames shall be porcelain enameled white, baked enameled white, or triglycidyl isocyanurate thermosetting polyester powder coated white.

If black characters are called for in the plans, they shall consist of embossed aluminum frames without reflectors or flat sheet aluminum. The frames shall be black porcelain enameled, baked enameled, or triglycidyl isocyanurate thermosetting polyester powder coated. The frames shall be fabricated from 0.040-inch thick sheet Aluminum Alloy 3003-H14, conforming to ASTM B 209. Mounting holes shall be provided within flat sheet aluminum frames to permit the use of screws, rivets, or other common fasteners.

Porcelain enameling shall conform to the requirements of the Porcelain Enamel Institute. For baked enameling, the frames shall be chemically cleaned, deoxidized, and coated with a light, tightly adherent, chromate conversion coating free of any powdery residue in conformance with Section 5, "Recommended Processing Methods," of ASTM B 449. After the chromate finish is obtained, legend frames shall receive an electrostatic application of white thermosetting primer of 0.005-inch thickness. The white thermosetting primer shall be an epoxy-ester resin cross linked with an amino resin which properties include corrosion resistance, high adhesion, flexibility, and impact resistance to prevent chipping and flaking.

After priming, frames shall be finished with a high-gloss ceramic white thermosetting enamel or a high-gloss ceramic black thermosetting enamel, as required, using the electrostatic application method. The high-gloss ceramic white thermosetting enamel shall be a non-oxidizing alkyd resin cross linked with an amino resin to produce a non-yellowing, gloss-retentive coating. It shall contain sufficient chalk-resistant titanium dioxide necessary to meet the requirements of ASTM D 476, Types III and IV. The high-gloss ceramic black thermosetting enamel shall be a non-oxidizing alkyd resin cross linked with an amino resin to produce a gloss-retentive coating. Coating thickness shall be a minimum of 0.001 inches. The specular gloss shall be 50 minimum when tested in accordance with ASTM D 523. For triglycidyl isocyanurate thermosetting polyester powder coating, the front and back surfaces of the aluminum frames shall be chemically cleaned, deoxidized, and coated with a light, tightly adherent, chromate conversion coating free of any powdery residue in conformance with Section 5, "Recommended Processing Methods," of ASTM B 449. The triglycidyl isocyanurate thermosetting polyester powder coat shall be applied in accordance with the specifications issued by the manufacturer and shall have a minimum thickness of 0.002 inches. The specular gloss shall be 50 minimum when tested in accordance with ASTM D 523.

Letter design of the upper-case and lower-case letters and numerals shall be Series E of the Standard Alphabets for Highway Signs, modified by widening the stroke width to

approximately one-fifth of the letter or numeral height. The upper-case letter shall be one and one-third times the loop height of the lower case letters.

Letter design of the capital letters shall be Series D of the Standard Alphabets for Highway Signs modified by widening the stroke width to approximately one-fifth of the letter or numeral height.

Self-plugging aluminum blind shoulder rivets or round-head wood screws, when used in black frames, shall be anodized black. All rivets used in embossed frames shall be 5/32-inch diameter, self-plugging aluminum blind shoulder rivets. The length of the rivets placed in the characters shall be at least 3/4 inch. All rivets shall extend through the panel face and be set tight. Rivets used in flat sheet aluminum characters shall be 5/32 inch in diameter and at least 5/8 inch in length.

608-2.15 Silk-Screened or Direct-Applied Characters:

Silk-screened letters, numerals, arrows, symbols, and borders, shall be applied on the retroreflective sheeting background of the sign by direct or reverse screen process. Messages and borders of a color darker than the background shall be applied to the retroreflective sheeting by direct process. Messages and borders of a color lighter than the sign background shall be produced by the reverse screen process.

Opaque or transparent colors, inks, and paints used in the screen process shall be of the type and quality recommended by the manufacturer of the retroreflective sheeting.

The screening shall be performed in a manner that results in a uniform color and tone, with sharply defined edges of legends and borders and without blemishes on the sign background that will affect intended use.

Signs, after screening, shall be air dried or baked in accordance with the manufacturer's recommendations to provide a smooth hard finish. Any signs on which blisters appear during the drying process will be rejected.

Direct-applied letters, numerals, symbols, borders, and other features of the sign message shall be cut from black opaque or retroreflective sheeting of the color specified and applied to the retroreflective sheeting of the sign background in accordance with the instructions of the manufacturer of the retroreflective sheeting and shall be applied by heat activation of the adhesive.

The retroreflective sheeting used for characters shall meet or exceed the minimum Specific Intensity Per Unit Area (SIA) of the background sheeting.

608-3 Construction Requirements:

608-3.01 Fabrication:

Fabrication of the sign panels shall be in accordance with the details shown on the plans and the requirements of these specifications. If additional details for sign panel fabrication are

required, the contractor shall submit shop drawings in accordance with the requirements of Subsection 105.03.

Panels shall be cut to size and shape and shall be free of buckles, warps, dents, cockles, burrs and defects resulting from fabrication.

Fabricated signs and overlay sheets shall be stored indoors and kept dry during storage. If packaged signs become wet, all packaging material shall be removed immediately and the signs allowed to dry. The signs may be repackaged using new dry materials. If outdoor storage is necessary, all packaging materials shall be removed. Signs shall be stored on edge, above ground, in an area where dirt and water will not contact the sign face. Materials used to support stored signs shall not contact sign faces.

608-3.02 Installation of Sign Panels:

The sign panels shall be installed on overhead sign structures and roadside sign supports in accordance with the details shown on the plans and in accordance with the recommendations of the manufacturers of the sign panel components.

Minor scratches and abrasions resulting from fabrication, shipping and installation of panels may be patched; however, patching shall be limited to one patch per 50 square feet of sign area with the total patched area being less than five percent of the sign area. Panels requiring more patching than the specified limit will be rejected. Patches shall be edge sealed by a method approved by the retroreflective sheeting manufacturer.

The heads of bolts on the panel face shall be anodized or painted to match the background or legend color in which they are placed. The nylon washers on the panel face shall be the color of, or shall be painted to match, the background or legend color in which they are placed. The sign manufacturer's name and date of installation shall be placed on the back of each sign in black, one-inch block letters. Use of felt markers for this purpose will not be permitted. Bolts shall be tightened from the back by holding the bolt head stationary on the face of the panel. Twisting of the bolt head on the panel face will not be allowed.

608-3.03 Miscellaneous Work (Sign Panels):

The work under this section shall also include furnishing all miscellaneous materials, tools, equipment and labor necessary to relocate exit panels to the right side of the parent sign panel; removing, cutting, and installing side trims and new or salvaged aluminum extrusions on existing sign panels; relocating large guide and exit gore signs; and cutting post tops on existing installations, as required on the plans.

608-3.04 Inspection:

An inspection of the completely installed sign panels will be made by the Engineer during the daytime and at night for proper appearance, visibility, color, specular gloss and proper installation.

Each sign panel face shall be cleaned thoroughly just prior to the inspection by a method recommended by the manufacturer. The cleaning solvent and cleaning material shall in no way scratch, deface or have any adverse effect on the sign panel components.

All apparent defects disclosed by the inspection shall be corrected by the contractor at no additional cost to the Department. If color variations or blemishes between sign panel increments are visible from a distance of 50 feet either during the day or at night, the panels shall be removed and replaced at no additional cost to the Department.

608-4 Method of Measurement:

Sign panels will be measured by the square foot for each type or types of sign panels furnished and installed. The area of each sign panel, except for warning, regulatory and marker sign panels, will be measured per plans dimensions.

For warning, regulatory and marker sign panels, the area of each sign panel will be measured to the nearest square foot and the areas will be determined as follows:

> The areas of each rectangular, square or triangular sign panel will be determined from the dimensions shown on the plans. The area of irregular shaped signs, such as stop signs and route markers, will be determined by multiplying the maximum height in feet by the maximum width in feet, using the dimensions shown on the plans.

Miscellaneous Work (Sign Panels) will be measured on a lump sum basis.

608-5 Basis of Payment:

The accepted quantities of each type of sign panel designated in the bidding schedule, measured as provided above, will be paid for at the contract unit price per square foot, complete in place.

Payment shall be made on the total area of each type of sign panel to the nearest square foot, except Route Shields and EXIT ONLY (For Installation On Sign Panels) which shall be paid for as part of the overall panel.

The contract unit price shall be full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for performing all the work involved in furnishing and installing the sign panels, complete in place, including furnishing and applying all retroreflective sheeting, all fastening hardware, all necessary sign supports, stringers and post ties, all as shown on the plans and as specified herein.

The accepted quantities of Miscellaneous Work (Sign Panels), measured as provided above will be paid for at the contract lump sum price, which price shall be full compensation for the work complete in place as shown on the plans and as described and specified herein.

SECTION 609 DRILLED SHAFT FOUNDATIONS:

609-1 Description:

609-1.01 General:

The work under this section shall include furnishing all materials and constructing reinforced concrete shafts formed within a drilled excavation. Each drilled shaft foundation shall consist of a shaft section with or without casing left in place, as directed or specified, with or without a rock socket or a belled footing, and shall be constructed in reasonably close conformity with the details and dimensions shown on the plans and the requirements of these specifications.

609-1.02 Certification:

The contractor shall be responsible to review all available geotechnical investigation reports, and its signature on the proposal form shall certify that the firm performing the drilled shaft operations, whether the prime contractor or a subcontractor, has completed this review. The geotechnical investigation reports are available at Contracts and Specifications Section, 1651 West Jackson, Phoenix, Arizona.

609-1.03 Installation Plan:

The contractor shall provide to the Engineer for review and approval a detailed installation plan containing the following information:

(1) List of proposed equipment to be used including cranes, drills, augers, bailing buckets, final cleaning equipment, desanding equipment, slurry pumps, sampling equipment, tremies or concrete pumps, casing, etc.

(2) Details of overall construction operation sequence and the sequence of shaft construction in bents or groups.

(3) Details of shaft excavation methods, including equipment and procedures for checking the dimensions and alignment of each shaft excavation.

(4) When slurry is required, details of the method proposed to mix, circulate and desand slurry, and methods proposed to comply with the requirements of Subsections 609-3.04(A) and 609-3.07(C), including disposal of the slurry.

(5) Details of methods to clean the shaft excavation.

(6) Details of reinforcement placement including support and centralization methods.

(7) Details of concrete placement.

(8) Details of casing dimensions, material and splice details.

(9) Details of concrete mix designs and mitigation of possible loss of slump during placement.

(10) List of work experience in previous similar projects.

(11) Other information shown on the plans or requested by the Engineer.

(12) Emergency horizontal construction joint method if unforeseen stoppage of work occurs.

The documentation required above shall be submitted to the Engineer not later than four weeks before work on shafts is to begin. The Engineer will review the submittal within 10 working days. No drilled shaft work shall be performed until the contractor's final submittal has been approved by the Engineer. Such approval will not relieve the contractor of responsibility for results obtained by use of the installation plan, or any of its other responsibilities under the contract.

609-2 Materials:

609-2.01 Concrete:

Concrete shall conform to the requirements of Section 1006 for the class and strength shown on the plans, with the following additions or modifications:

(A) Cement:

Where concrete is placed in drilled shaft excavations containing slurry or water, the cement content of the concrete shall be between 660 and 750 pounds per cubic yard.

(B) Aggregate:

Maximum aggregate size shall be limited to 1/5 of minimum clear bar spacing (vertical and horizontal), not to exceed one inch.

609-2.02 Reinforcing Steel:

Reinforcing steel shall conform to the requirements of Section 1003. Welded splices will not be allowed except as shown on the plans.

609-2.03 Casing:

Casing shall be steel and may be of unit or sectional construction. The casing shall be of sufficient strength to withstand handling and driving stresses, to withstand the pressure of concrete and the surrounding earth and to prevent seepage of water. Steel shall conform to the requirements of AASHTO M 270 (ASTM A 709), Grade A 36, unless otherwise specified.

Should telescoped casing be used, the contractor shall not allow concrete to overfill any interior casing. Spillage must be removed from the annulus, or the shaft shall be declared deficient.

Temporary casing shall be clean, inside and out, prior to placement in the excavation. All casing shall be handled so as to limit distortion to plus or minus two percent of diameter. No side shear capacity will be allowed where temporary casing installed becomes permanent. If approved by the Engineer and if conditions permit, temporary casings may be corrugated and non-watertight.

The contractor shall be responsible to compensate for loss of frictional capacity in the cased zone if temporary casing is abandoned in the shaft. Such modifications shall be at no additional cost to the Department.

609-3 Construction Requirements:

609-3.01 General:

The methods and equipment used shall be suitable for the intended purpose and materials encountered. Either the dry method, wet method, temporary casing method or permanent casing method, as defined by AASHTO Standard Specifications for Highway Bridges, Division II, Section 5, shall be used as necessary to produce sound, durable concrete foundation shafts free of defects, subject to approval of the Engineer. The permanent casing method shall be used only when required by the plans or authorized by the Engineer.

If at any time during the construction of the drilled shafts the Engineer determines that the equipment, materials, employees, or procedures are such that defects in the work may occur, the Engineer may stop the work until appropriate changes are made by the contractor. In no case shall the contractor be relieved of its responsibility for constructing acceptable drilled shaft foundations.

609-3.02 Confirmation Shafts:

When required in the Special Provisions or when indicated on the plans, the contractor shall construct a confirmation shaft to determine the adequacy of the contractor's equipment, materials, employees, and procedures for completion of the drilled shaft foundations in accordance with the requirements of the plans, specifications, and installation plan. The confirmation shaft normally will be the first drilled shaft foundation developed, subject to the approval of the Engineer.

The location of all confirmation shafts shall be as shown on the plans or as directed by the Engineer. The confirmation shaft holes shall be completed in the same manner as other production shafts. The contractor shall revise its methods and equipment as necessary at any time during the construction of the confirmation shaft hole to satisfactorily complete the excavation. When the contractor fails to satisfactorily demonstrate the adequacy of its methods, procedures, or equipment; or when unforeseen conditions require revision, such as the need for slurry; the installation plan shall be revised and the adjacent shaft shall be

designated as the confirmation shaft for the revised installation plan, as approved by the Engineer.

When shown on the plans or when ordered by the Engineer in writing, the reaming of bells or development of rock sockets at specified confirmation shaft holes shall be required to establish feasibility in a specific soil strata.

609-3.03 Excavation:

The contractor shall perform all excavation required for the shafts, rock sockets or belled footings, through whatever substances encountered, to the dimensions and elevations shown on the plans or ordered by the Engineer. Unless otherwise shown on the plans, the maximum deviation from plumb shall be not more than one and one half percent. The maximum permissible variation of the design center axis for both the borehole and rebar cage at the top shall be five percent of the shaft diameter, not to exceed three inches from its project plan location. The contractor shall determine plumbness by plumb lines in dry excavations and by Kelly bar position readings at 10-foot intervals in wet excavations, or as approved by the Engineer. The contractor shall provide the Engineer with these readings for each drilled shaft constructed to verify plumbness. When bells or rock sockets are required, they shall be excavated so as to form a bearing area of the size and shape shown on the plans.

If satisfactory material is not encountered at plan elevation, the bottom of any drilled hole may be lowered, at the direction of the Engineer. Alteration of plan depth will be made to satisfactorily comply with design requirements. Reinforcing steel and concrete shall not be placed in the shaft until this final elevation has been established. Raising of the foundation elevation shall require approval by the Engineer.

If caving conditions are encountered, no further drilling will be allowed until a construction method is employed that will prevent excessive caving and which is acceptable to the Engineer. If casing is proposed, the shell shall be clean and shall extend to the top of the drilled shaft excavation. The inside diameter of the casing shall not be less than the specified size of the shaft unless approved by the Engineer. The outside diameter of the shaft shall not exceed plan dimension by more than six inches unless use of telescoping casing or surface casing is allowed by the installation plan.

Temporary surface casings may be used to aid shaft alignment and position, and to prevent sloughing of the top of the shaft excavation, if approved by the Engineer.

If the Engineer determines that the amount of caving is within acceptable limits and the contractor elects to drill under the same methods and procedures, the excavation shall be filled with concrete at no additional cost to the Department, regardless of the extent. Any excavation beyond the dimensions shown on the plans where casings are not used shall be filled with concrete at no additional cost to the Department.

If the use of drilling slurry is to be employed, either with or without the use of casing, the contractor shall use a method of construction which will allow completion of the drilled shaft in a continuous manner without any mixing of concrete and drilling slurry.

Material excavated from shafts and bells and not incorporated elsewhere on the project shall be disposed of as approved by the Engineer.

When the plans indicate drilled shafts are to be constructed within embankments, the embankments shall be constructed prior to drilling, except when approved otherwise by the Engineer.

After the completion of the drilled shaft excavation and prior to the placement of the reinforcing steel cage and concrete, all loose material shall be machine cleaned from the shaft. A flight auger or other equipment, approved by the Engineer, shall be used for cleaning dry excavations where slurry or ground water is not present. Where slurry or ground water is present, the excavation shall be cleaned with a clean-out bucket or similar type of equipment, as approved by the Engineer.

All open excavations shall be covered at the end of each shift in a manner approved by the Engineer.

609-3.04 Drilling Slurry:

(A) General Requirements:

The contractor shall provide a specialist experienced in the slurry drilling process to design and monitor the slurry. The specialist shall be present at all times when the slurry method is used, and shall supervise the testing required in Subsection 609-3.04(B). Only commercially prepared mineral slurries shall be employed when slurry is used in the drilling process. The slurry shall have both a mineral grain size that will remain in suspension and sufficient viscosity and gel characteristics to transport excavated material to a suitable screening system. The percentage and specific gravity of the material used to make the suspension shall be sufficient to maintain the stability of the excavation and to allow proper concrete placement. During construction, the level of the mineral slurry in the shaft excavation shall be maintained at a level not less than four feet above the highest expected piezometric pressure head along the depth of the shaft. In the event of a sudden significant loss of slurry to the hole, the construction of that foundation shall be stopped until either a method to stop slurry loss or an alternative construction procedure has been approved by the Engineer.

The mineral slurry shall be premixed thoroughly with clean, fresh water. Adequate time, as prescribed by the mineral manufacturer, shall be allotted for hydration prior to introduction into the shaft excavation. Slurry tanks of adequate capacity shall be required for slurry circulation, storage, and treatment. No excavated slurry pits shall be allowed in lieu of slurry tanks. No mixing of slurry shall be allowed in the drilled shaft excavation. Slurry shall not stand for more than four hours in the excavation without agitation. If this is not possible, excavation sidewalls shall be cleaned to remove filter cake and the slurry tested for compliance with Table 609-3.04(A). Slurry density shall be increased by adding barite only when sodium bentonite is the mineral.

Desanding equipment shall be provided by the contractor as necessary to control slurry sand content within the acceptable values shown in Table 609-3.04(A) at any point in the bore

hole. Desanding will not be required for setting casing. The contractor shall take all steps necessary to prevent the slurry from "setting up" in the shaft. Such methods may include agitation, circulation and/or adjusting the properties of the slurry. The contractor shall dispose of all slurry off site at an approved disposal site.

TABLE 609-3.04(A)
(Sodium Bentonite or Attapulgite in Fresh Water)

Property: units	**Range of Values ***		**Test Method**
	At Time of Introduction of Slurry	**In Hole at Time of Concreting**	
Density: pcf	64.3 - 69.1	64.3 - 75.0**	Density Balance
Yield Point: pascals	Bentonite 1.25 - 10	10 Max.	Rheometer
	Attapulgite 2 - 15	15 Max.	Rheometer
or			
Viscosity: seconds/quart	28 - 45	28 - 45	Marsh Cone
pH	8 - 11	8 - 11	pH Paper or pH Meter
Sand Content: % by volume	0 - 4	0 - 10	API Sand Content Kit

* Above 68 degrees F
** 85 pcf maximum when using Barite.

(B) Slurry Inspection and Testing:

The contractor shall have suitable apparatus available at the site capable of obtaining slurry samples at any depth within the drilled shaft excavation. All equipment required for the tests specified in this section shall be provided by the contractor, and the tests shall be performed by the contractor under the observation of the Engineer.

Control tests using suitable apparatus shall be carried out by the contractor on the mineral slurry to determine density, viscosity or yield point, pH and sand content. A range of values for those physical properties is shown in Table 609-3.04(A); but, in all cases, at least the minimum value necessary to achieve borehole stability shall be utilized.

Tests to determine density, viscosity or yield point, and pH value shall be done by the contractor during the shaft excavation to establish a consistent working pattern. A minimum of four sets of tests shall be made during the first eight hours of slurry use. When the results show consistent behavior, the testing frequency may be decreased to one set every four hours of slurry use.

The contractor shall ensure that heavily contaminated slurry suspension, which could impair the free flow of concrete, has not accumulated in the bottom of the shaft. Prior to placing concrete in any shaft excavation, the contractor shall take slurry samples using a sampling tool suitable for recovery of slurry samples at any desired elevation in the excavation. Slurry samples shall be extracted from the base of the shaft and at 10 feet up the shaft until samples produce acceptable values for density, viscosity or yield point, pH, and sand content.

When any slurry samples are found to be unacceptable, the contractor shall take whatever action is necessary to bring the mineral slurry within specification requirements. Concrete shall not be placed until resampling and testing results produce acceptable values.

Reports of all tests required above, signed by an authorized representative of the contractor, shall be furnished to the Engineer on completion of each drilled shaft.

609-3.05 Integrity Testing:

Drilled shaft excavation inspections shall be performed by the contractor and will be reviewed by the Engineer. The contractor shall provide suitable equipment and facilities to perform the required inspections so that the Engineer may evaluate completed excavations for correct alignment and dimensions.

Reinforcing steel and concrete shall not be placed in the drilled shaft excavation until the Engineer has made an evaluation and given approval.

Each drilled shaft foundation completed by a wet excavation method shall be inspected by means of a gamma-gamma logging device or by cross-hole sonic logging survey. The contractor shall furnish and install 2-1/2 inch Schedule 80 PVC pipe for gamma-gamma logging, or two-inch Schedule 40 black steel pipe for cross-hole sonic logging. The pipe shall be joined to provide a clean and unobstructed opening from the top of the drilled shaft foundation to within one foot of the tip in accordance with the details shown on the plans. The PVC pipe shall be capped top and bottom, filled with water, and securely tied to the reinforcing steel in a straight line to prevent displacement during handling and concrete placement and to permit the logging device to pass from top to bottom. The black steel pipe shall not require water filling. The pipe shall be secured to the inside of the reinforcing cage. The contractor shall provide the testing equipment, perform the inspection, and furnish test results to the Engineer.

If the testing indicates the presence of voids, intrusions or zones of unconsolidated concrete in the drilled shaft foundation, or if the Engineer determines that construction defects may have occurred, or if testing cannot be performed because of blockage of the tubes, the contractor shall core-drill or otherwise determine the extent of any defects in the concrete as approved by the Engineer. The contractor shall repair, replace or supplement the defective work in a manner approved by the Engineer, at no additional cost to the Department.

After all inspection has been completed, all holes and test pipes in all drilled shaft foundations shall be filled with an approved grout.

609-3.06 Reinforcing Steel, Cage Construction and Placement:

The reinforcing steel cage for the drilled shaft, consisting of longitudinal bars and spiral hooping or lateral ties shall be completely assembled and placed into the shaft as a unit. The reinforcing steel unit shall not be placed until immediately before concreting operations are to be started and shall be placed in accordance with the details shown on the plans.

The reinforcing cage shall be adequately supported and anchored from the top to prevent movement from the required location during and for four hours after completion of concrete placement. The rebar cage shall not rest directly on the bottom of the excavation. Spacers shall be at sufficient intervals along the shaft to ensure concentric location of the reinforcing cage for the entire length of shaft. Only spacers approved by the Engineer shall be allowed, but in no case shall "dobies" or other rectangular "blocks" tied to the reinforcing steel be allowed.

If the shaft is lengthened and the plans indicate full depth reinforcement, the Engineer shall be notified to determine if extension of the reinforcement is needed. The Engineer will provide details for additional reinforcing if required. Such additional reinforcing will be paid for in accordance with Subsection 109.04.

The contractor shall submit a written request to the Engineer for approval of any variation from the splices for reinforcing steel specified in the contract documents.

All reinforcing cages shall be fabricated and supported to avoid damage during the lifting and placing. Any temporary bracing and supports shall be removed prior to final placement.

609-3.07 Concrete Placement:

(A) General:

The contractor shall begin placement of concrete within 24 hours after the completion of the drilled shaft excavation. All concrete shall be placed in accordance with Section 601 and as specified herein. If slurry excavation is used, concrete shall be placed the same day the excavation is completed. Unless otherwise specified in the project documents, or as directed by the Engineer, the slump shall be between five and six inches for dry, uncased excavations. For all others, the concrete slump shall be eight ± one inches at the time placement begins.

Prior to concrete placement, the contractor shall make all necessary arrangements to assure the uninterrupted delivery of concrete so that all drilled shaft foundations will be constructed without cold joints. During concrete placement, from start to finish, the rate of rise of the top of concrete in the drilled shaft shall be at least 40 feet per hour.

Tremie downpipes and pump pipes shall be made of steel; no aluminum shall be allowed. The inside diameter of the tremie pipe shall be at least 10 inches. The inside diameter of the pump pipe shall be at least five inches.

(B) Placement in Dry Excavations:

For placement in dry excavations, concrete may be placed by free fall except in cohesionless soils or where other caving conditions exist. The contractor shall prevent concrete from striking either the reinforcing cage or excavation side walls during free fall. Where free fall cannot be used, concrete shall be placed through a suitable clean downpipe.

Concrete vibration for the full height of the shaft is not necessary to achieve proper consolidation of the concrete. However, the shafts shall be vibrated in the top 10 feet.

For dry shafts, the maximum depth of water in the bottom of the drilled shaft excavation at the time of concrete placement shall be three inches.

(C) Placement under Slurry or Water:

Concrete shall be placed by tremie methods or by pumping. Care shall be taken to ensure that all the fluid and suspended solids are expelled from the excavation during concrete placement. If concrete is placed by pumping, it shall be in accordance with the requirements of Subsection 601-3.03(C).

The contractor's installation plan shall demonstrate the procedures used to determine when the tremie pipe is to be raised during concrete placement. The procedure shall assure that the opening of the tremie pipe will be deeper than five feet below the surface of the concrete at all times, and that a void will not be created by lifting the tremie when there is insufficient head of concrete. A rapid raising or lowering of the tremie will not be permitted.

In order to prevent contamination of concrete placed initially, the lower end of the pump or tremie pipe shall be provided with either a valve, sealable cap, or plug ("pig"). The discharge end shall be placed at the bottom of the excavation prior to commencement of concrete placement. If a plug is used, it shall be inserted at the top after the pipe has been set in place. Concrete shall then be placed by pushing the plug ahead, separating the concrete from the drilling fluid. Only when the tremie pipe is completely filled shall the open end be lifted off the bottom. The first portion of the concrete flow that comes to the top of the shaft shall be displaced out of the shaft excavation until clean, fresh concrete is expelled.

Slurry ejected during concrete placement may be reused provided that it is screened to remove gravel chips or other granular materials, and providing the slurry meets acceptance criteria. Slurry to be discarded shall be disposed of in a manner approved by the Engineer.

Concrete placed under slurry or water shall not be vibrated, except that the top five feet of the shaft shall be vibrated after the slurry or water and contaminated concrete have been totally expelled from the shaft. If temporary casing is used, the vibration shall occur after the casing has been removed.

609-3.08 Casing Removal:

During removal of any casing, a sufficient head of not less than five feet of fluid concrete in the tremie pipe shall be maintained above the level of concrete in the shaft (outside the tremie pipe), except at the top of the shaft. All contaminated concrete shall be removed from

the shaft. Temporary casings shall be removed while the concrete slump is a minimum of four inches. The contractor shall maintain a minimum five-foot head of concrete in the casing as it is being removed. Movement of the casing by exerting downward pressure and tapping to facilitate extraction, or extraction with a vibratory hammer will be permitted. Casing extraction shall be at a slow, uniform rate with the force in-line with the shaft axis.

Due care shall be exercised to prevent upward movement of the shaft concrete and reinforcing steel during casing extraction. Upward movement beyond one inch, excluding movement due solely to tension on the top anchoring system, may indicate serious concrete separation or necking problems at the bottom of the casing. The contractor shall be responsible for corrective action which may include leaving the casing in place and compensating for the loss of frictional capacity in the resulting cased zone.

609-4 Method of Measurement:

Drilled shafts will be measured to the nearest linear foot from the top elevation of the shaft to the top elevation of the rock socket stratum, if required, or to the actual bottom of the shaft, as shown on the plans, or as determined in the field by the Engineer.

Rock sockets, when specified, will be measured to the nearest linear foot from the top elevation of the rock socket stratum to the actual bottom of the shaft, as shown on the plans, or as determined in the field by the Engineer.

Bell sections will be measured by the unit for each type of foundation constructed.

609-5 Basis of Payment:

The accepted quantities of drilled shafts and rock sockets, measured as provided above, will be paid for at the contract unit price per linear foot for the diameter designated in the bidding schedule, complete in place, including excavation; drilling slurry; metal casing; steel reinforcing; Portland cement concrete; any needed forming, curing and finishing; exposing of concrete and the subsequent repair of foundations; furnishing all materials, equipment, and labor for splicing of reinforcing steel; conduit and equipment for gamma-gamma or sonic cross-hole logging; and all required tests. No additional payment will be made for metal casing that is to remain in place. No additional payment will be made for confirmation shafts, the cost considered to be included in the cost of constructing the drilled shaft foundation.

Payment for belled sections will be at the contract unit price for each type of foundation constructed, including excavation and concrete beyond the diameter of the shaft.

Obstructions will be defined as either material or objects of excessive dimension which could not be reasonably inferred from the geotechnical and foundation report. Drilling tools which are lost in the excavation shall not be considered obstructions. Payment for obstructions will be made in accordance with the provisions of Subsection 109.04.

SECTION 610 PAINTING:

610-1 Description:

The work under this section shall consist of furnishing paint and other materials and painting concrete, structural steel, or other surfaces where shown on the plans in accordance with the requirements of these specifications. The work shall include preparation of the surfaces to be painted, the protection and drying of the paint coatings and the protection of pedestrian, vehicular or other traffic near or under the work from paint spatter and disfigurement.

610-2 Materials:

Paint shall conform to the requirements of Section 1002, unless otherwise specified.

610-3 Construction Requirements:

610-3.01 Weather Conditions:

Paint shall be applied only on thoroughly dry surfaces and only when the atmospheric temperature is in the range from 50 degrees F to 100 degrees F, inclusive, and when the relative humidity is at or below 75 percent. Paint shall only be applied to a surface which is at least 5 degrees F above the dew point. The surface temperature should remain above the minimum temperature specified above until the paint is thoroughly dry. Paint shall not be applied when the air is misty or when weather conditions exist which might damage the work. If fresh paint is damaged by the elements, it shall be replaced or repaired by the contractor at no additional cost to the Department. The contractor may provide suitable enclosures to permit painting during inclement weather.

610-3.02 Surface Cleaning:

(A) Metal Surfaces:

All surfaces of structural steel or other metals, except galvanized surfaces, shall be cleaned prior to painting.

All surfaces of new structural steel or other metals which are to be painted shall be blast cleaned to a near-white finish in accordance with SSPC Standard SP10, unless otherwise specified or approved in writing by the Engineer.

When repainting existing steel structures, the method of cleaning will be specified in the Special Provisions. Areas not designated for repainting which are damaged as a result of the contractor's operations shall be repaired by the contractor, at no additional cost to the Department, and as approved by the Engineer.

(1) Blast Cleaning:

All dirt, rust, old paint, mill scale and other foreign material shall be removed from steel or other metal surfaces with an approved blast cleaning apparatus. Blast cleaning shall leave all surfaces with a dense, uniform anchor pattern or profile of 1.0 mils to 3.0 mils, as measured with an approved surface profile comparator or pressed film replica tape.

Abrasives used for blast cleaning shall be clean dry sand, mineral grit, steel shot, or steel grit and shall be graded to produce satisfactory results. The use of other abrasives will not be permitted unless approved in writing by the Engineer.

When blast cleaning is being performed near machinery, all journals, bearings, motors and moving parts shall be sealed against entry of abrasive dust.

Blast cleaned surfaces shall be primed or treated the same day blast cleaning is done, unless otherwise authorized by the Engineer. If cleaned surfaces rust or are contaminated with foreign material before painting is accomplished, they shall be recleaned by the contractor at no additional cost to the Department.

(2) Steam Cleaning:

All dirt, grease, loose chalky paint or other foreign material which has accumulated on previously painted surfaces shall be removed with a steam cleaning apparatus prior to all other phases of cleaning. It is not intended that sound paint be removed by this process. After steam cleaning, any paint which has become loose, curled, lifted or loses its bond to the preceding coat or coats shall be removed to sound paint or metal surface by the contractor at no additional cost to the Department.

A detergent shall be added to the feed water of the steam generator or applied to the surface to be cleaned. The detergent shall be of such composition and shall be added in such quantity that the specified cleaning is accomplished.

Any residue, detergent or other foreign material which may accumulate on cleaned surfaces shall be removed by flushing with fresh water.

Steam cleaning shall not be performed more than two weeks prior to starting painting operations or other phases of cleaning.

Subsequent painting shall not be performed until the cleaned surfaces are thoroughly dry and in no case in less than 24 hours after cleaning.

(3) Hand Cleaning:

Manual or powered wire brushes, hand scraping tools, power grinders or sandpaper shall be used to remove all dirt, loose rust, mill scale, or paint which is not firmly bonded to the surfaces.

(4) Water Blast Cleaning:

Water blast cleaning shall be done in accordance with NACE (National Association of Corrosion Engineers) Standard RP-01-72 with normal water, no additives to the water will be allowed. All areas of oil and grease on surfaces to be coated shall be hand cleaned with clean petroleum solvents. The solution of solvent and contaminates shall be wiped clean and the surfaces allowed to air dry prior to the water blast cleaning. The contractor shall not

use power spray equipment or similar methods to apply the solvent. All the surfaces to be coated shall be power washed with a water pressure of not less than 2000 PSI and not greater than 5000 PSI. The water blasting equipment shall have a minimum water usage of 5 gallons/minute.

Water blast cleaning shall be performed no more than two weeks prior to the start of painting operations or other phases of cleaning.

Subsequent painting shall not be performed until the cleaned surfaces are thoroughly dry and in no case less than 24 hours after cleaning.

(B) Concrete Surfaces:

Prior to painting concrete surfaces, laitance and curing compounds shall be removed from the surface by abrasive blast cleaning in accordance with the requirements of ASTM D 4259. The cleaned surface shall have a roughened, textured appearance consistent with the surrounding concrete surface.

Concrete surfaces shall be thoroughly dry and free of dust at the time the paint is to be applied. Any artificial drying procedures and methods shall be subject to approval by the Engineer.

(C) Surfaces other than Metal or Concrete:

Prior to painting any surfaces other than metal or concrete, the surface shall be in accordance with the manufacturer recommendations and as approved by the Engineer.

610-3.03 Application:

Painting shall be accomplished in a neat and workmanlike manner.

For painting metal surfaces, paint shall normally be applied by spraying with limited use of hand brushes or rollers except that aluminum paint, as specified in Subsection 1002-2.03, shall be applied by spraying.

For painting concrete surfaces, the contractor shall develop an Application Plan according to the manufacturer's written recommendations. The Plan shall include:

(1) Rate of application.
(2) Number of necessary coats (minimum of two coats).
(3) Ambient air temperature.
(4) Ambient surface temperature.
(5) Application equipment.
(6) Qualification of workers.
(7) Safety and damage protection.
(8) Proposed surface preparation.

For painting concrete surfaces, the contractor shall apply all paint applications to a test specimen or to the concrete surface, according to Application Plan, for the subsequent approval of the Engineer. For paints not on the Approved Products List, a test specimen will be used for testing the performance requirements indicated in Section 1002. The contractor shall refinish the test inspection areas to match the paint finish of the surrounding concrete surfaces.

610-3.04 Protection Against Damage:

The contractor shall provide protective devices as necessary to prevent damage to the work and to other property or persons from all cleaning and painting operations.

Paint or paint stains which result in an unsightly appearance on surfaces not designated to be painted shall be removed or obliterated as approved by the Engineer.

All painted surfaces that are marred or damaged as a result of the contractor's operations shall be repaired with materials and to a condition equal to that of the paint coating specified herein.

Upon completion of all painting operations and of any other work the painted surfaces shall be thoroughly cleaned.

610-3.05 Painting:

(A) Metal Surfaces:

(1) General:

All surfaces of new metals shall be painted with one shop coat (primer) and two field coats (the intermediate coat and topcoat), unless otherwise specified.

The dry film thickness of the paint will be measured in place with a calibrated magnetic film thickness gauge in accordance with SSPC Standard PA2.

If the minimum dry film thickness is exceeded, it shall be limited to that which will result in uniform drying throughout the paint film.

(2) Primer:

The primer shall conform to the requirements of Subsection 1002-2.01. The dry film thickness of the primer shall not be less than 2.0 mils, and be sufficient to cover the blast profile pattern.

A deep profile pattern from steel shot blasting may require additional applications of primer to obtain sufficient coating of the steel surface.

After structural steel has been fabricated, blast cleaned and accepted by the Engineer, all surfaces, except metal surfaces which are to be embedded in concrete, or within three inches of a high strength bolted connection, shall be painted with a primer.

Structural steel which is to be welded shall not be painted before welding is complete. If it is to be welded only in the fabricating shop and subsequently erected by bolting, it shall receive one coat of primer after the shop welding is completed. Areas of structural steel to be field welded shall be masked and the remainder of the steel shall be given one coat of primer.

As soon as practicable after being accepted by the Engineer and prior to removal from the shop, machine-finished surfaces shall be primered with a rust inhibitor which can easily be removed. Surfaces of milled or finished iron and steel castings shall be painted with one coat of primer.

Erection marks for field identification of steel members and weight marks shall be painted upon surface areas previously painted with the primer.

(3) Intermediate Coat:

The intermediate coat shall be appropriately tinted to contrast with the primer and shall conform to the requirements of Subsection 1002-2.01. The dry film thickness of the intermediate coat shall not be less than 2.0 mils.

After erection of steel structures has been completed, including all riveting, welding, bolting and any straightening of bent metal, all adhering rust, scale, dirt, grease and other foreign material shall be removed as specified under Subsection 610-3.02. All areas where the primer is damaged or deteriorated shall be thoroughly cleaned and spot painted with the same type of paint used for the primer and to the specified dry film thickness.

When the spot painting coat is thoroughly dry, the intermediate coat shall be applied. In no case shall a succeeding coat be applied until the previous coat has dried throughout the full thickness of the paint film.

(4) Topcoat:

The topcoat shall conform to the requirements of Subsection 1002-2.01.

All small cracks and cavities which have not become sealed in a watertight manner by the intermediate coat shall be filled before the topcoat is applied.

At the option of the contractor, the intermediate coat and the topcoat may be applied in the shop. When finished coats are applied in the shop, the contractor shall repaint all damaged or deteriorated areas in the field as directed by the Engineer.

The dry film thickness of the topcoat shall be not less than 2.0 mils.

(B) Concrete Surfaces:

When painting is specified on the plans or in the special provisions, acrylic emulsion paint conforming to the requirements of Subsection 102-2.04, shall be applied to the exposed concrete surfaces tabulated below, except that sidewalks, appurtenant curbs, downdrains, and bridge deck surfaces shall be excluded.

All concrete shall be finished and cured in accordance with the requirements of the specifications prior to the application of the paint.

(1) Cast-in-Place Box Girder Bridges:

All surfaces of the superstructure, including the sides and bottoms of the box girders, shall be painted.

(2) Pre-cast I-Girder Bridges:

Bridge structures with vehicular traffic passing beneath at posted speeds of less than 55 miles per hour, or with pedestrian traffic beneath, shall be painted on all surfaces of the superstructure including both sides and bottoms of the pre-cast girders and the underside of decks.

Bridge structures with vehicular traffic passing beneath at posted speeds of 55 miles per hour or more, and with no pedestrian traffic beneath, shall be painted on all surfaces of the superstructure with the exception of the sides of the interior girders, the interior side of exterior girders, and the underside of the deck.

(3) Pre-cast Box and Slab Girder Bridges:

All surfaces of the superstructure including the sides of exterior girders and the bottom surfaces of the box or slab girder when exposed to traffic view shall be painted.

(4) Bridge Substructure and Walls:

All surfaces of bridge piers, including the pier caps and bottoms of integral pier caps, piles, columns, parapet walls and abutments, concrete retaining walls and noise barrier walls shall be shall be painted to at least one foot below finished grade.

(5) Barriers:

All surfaces of bridge barriers and the sides and tops of permanent barriers not adjacent to the traveled way shall be painted.

(C) Surfaces other than Metal or Concrete:

Surfaces other than metal or concrete shall be painted as recommended by the paint manufacturer and as approved by the Engineer.

All miscellaneous steel items that are not elements of bridges, cantilever sign supports, or bridge truss sign structures, may be hand-cleaned and have the required field paint coats applied in the shop.

610-3.06 Painting Damaged Galvanized Coating:

Areas of galvanized coating damaged due to welding after fabrication or due to handling, shall be roughened by sanding or acid and the roughened areas shall be painted with at least one full coat of zinc paint, conforming to the requirements of Subsection 1002-2.02.

610-4 Blank

610-5 Basis of Payment:

No measurement or payment will be made for painting as specified herein and on the plans, or for independent laboratory tests, surface preparation, and supplying samples, the cost being considered as included in the prices paid for the various contract items of work involving painting.